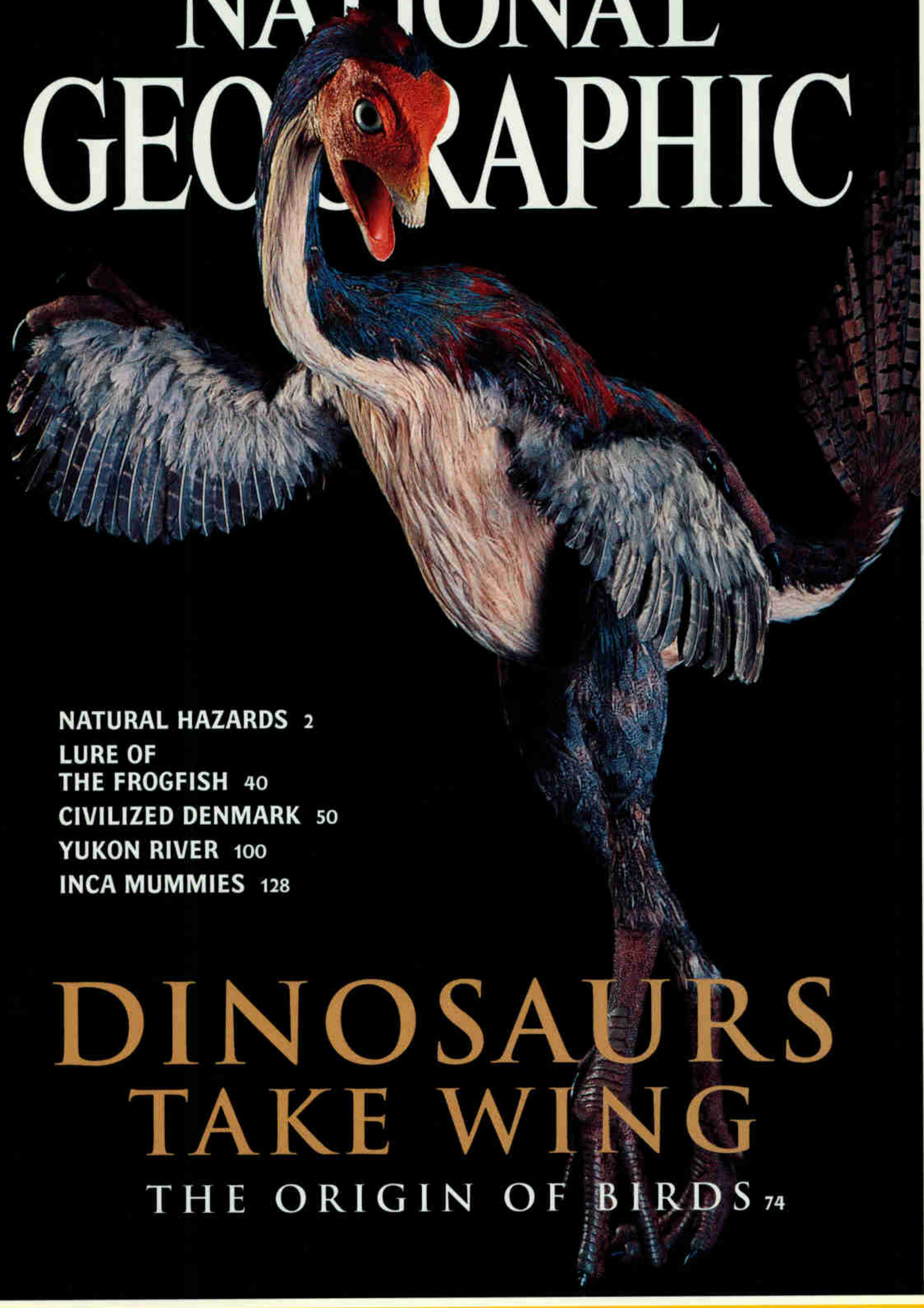
DOUBLE MAP SUPPLEMENT: NATURAL HAZARDS OF NORTH AMERICA

VOL. 194, NO. 1 JULY 1998

NATIONAL GEOGRAPHIC



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OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

NATURAL HAZARDS OF NORTH AMERICA

Produced by National Geographic Maps for National Geographic Magazine

NATIONAL GEOGRAPHIC SOCIETY

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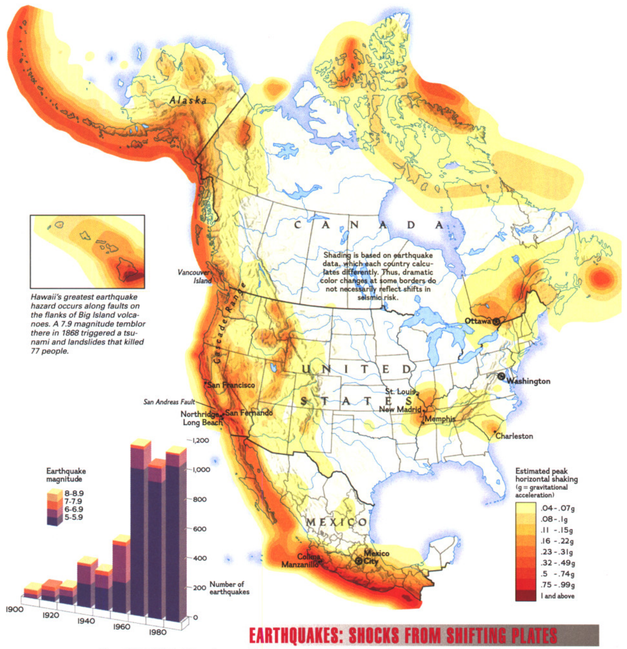
Washington, D.C., July 1998

Disaster can strike as quickly as lightning, though it may evolve as slowly as geologic time, depending on its source. And sources abound. Inspired by the UN's International Decade for Natural Disaster Reduction, more than 50 scientists from Canada, the United States, and Mexico have spent three years in a cooperative effort to map areas of potential disaster in their countries. The resulting maps, shown here, illustrate for the first time the reach of natural hazards across national borders. "We're keen to promote awareness of vulnerability," says project leader Chris Tucker of Emergency Preparedness Canada. Such awareness may help lessen tragic consequences when natural disasters strike.

WARREN FAIDLEY, WEATHERSTOCK

Supplement to NATIONAL GEOGRAPHIC, July 1998

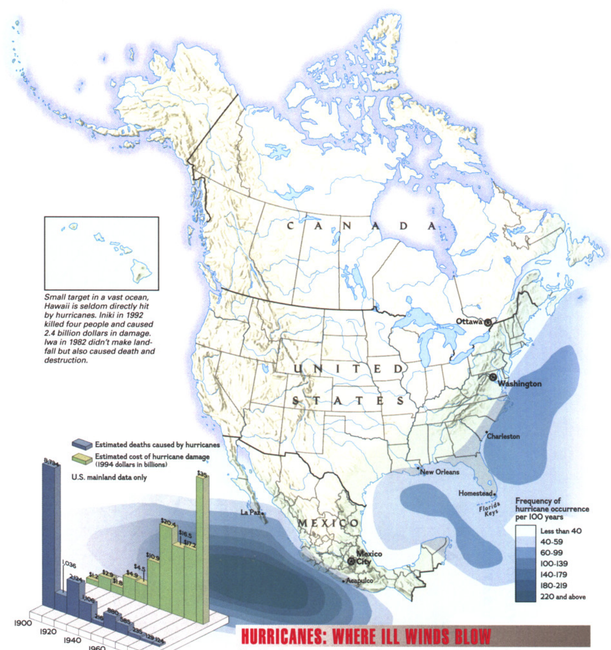


Hawaii's greatest earthquake hazard occurs along faults on the flanks of Big Island volcanoes. A 7.9 magnitude temblor there in 1868 triggered a tsunami and landslides that killed 77 people.

Since 1900, 4,643 sizable quakes have been recorded in Canada, Mexico, and the U.S. Only 17 of those have been magnitude 8 or greater, with one off Canada's west coast and eight each in Mexico and Alaska. The apparent increase in earthquakes is due to improved reporting.

EARTHQUAKES: SHOCKS FROM SHIFTING PLATES

The big one. It may not be imminent, but it is inevitable. The greatest earthquake hazard exists where one tectonic plate collides with, grinds past, or dives under another. Plate subduction under Alaska and southwestern Mexico make them the continent's most quake-prone spots, with each having many more strong temblors than California. California's San Andreas Fault is also an active seismic zone. The Cascadia subduction zone potentially could produce quakes stronger than those from California's faults, threatening cities in the Pacific Northwest. The Cascadia zone also makes people on Canada's west coast that nation's most at-risk group. Though less seismically active, the East has also felt huge quakes. Because eastern underground rock is more rigid than that in the West, seismic waves travel farther. A repeat of the 1811-12 quakes in Missouri, which ranged from 7.8 to 8.1 in magnitude, could cause damage from St. Louis to Memphis.



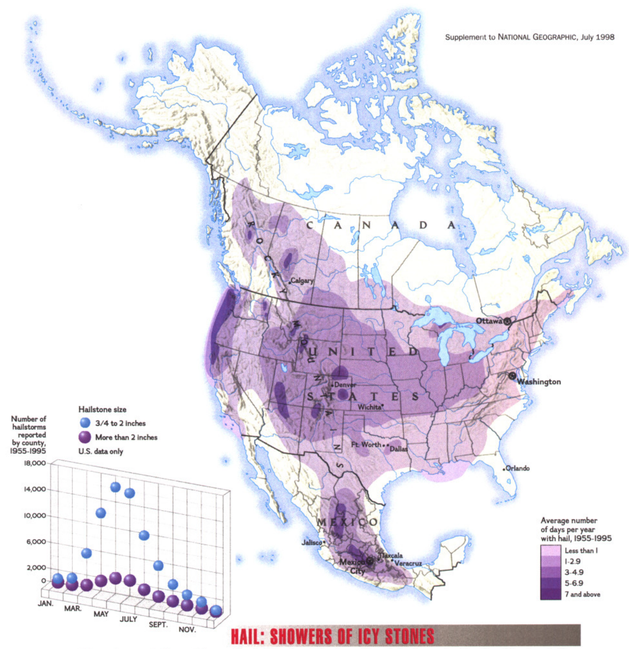
There's good news and bad on the hurricane front. Deaths have fallen with advances in early-warning technology. But with increased coastal development, many more people are vulnerable to hurricanes, and costs have soared. Damage in the 1990s tops that for the '70s and '80s combined.

HURRICANES: WHERE ILL WINDS BLOW

"In virtually every coastal city of any size from Texas to Maine . . . the United States is building toward a hurricane disaster." So concludes a recent report from the National Oceanic and Atmospheric Administration. Coast-hugging crowds are vulnerable to storm-surge flooding, which causes 90 percent of hurricane deaths. The Florida Keys are particularly at risk as they have only one road for evacuation.

Florida, Texas, Louisiana, and the Carolinas get walloped most, during a season that peaks in August and September. Though winds often weaken over land, hurricane rains can cause ruinous flooding well into Canada. Almost twice as many hurricanes form in the Pacific as in the Atlantic; in each case most spin harmlessly out to sea.

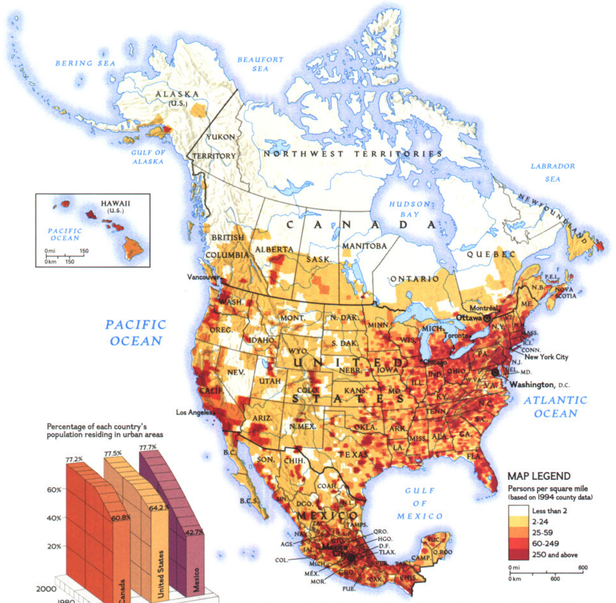
On average, 1.6 hurricanes make landfall—meaning the eye crosses land—in the U.S. each year. Yet severe damage from winds, rains, and hurricane-spawned tornadoes often occurs hundreds of miles from the eye.



Balmy afternoons in May and June have seen most of the nearly 91,000 hailstorms reported since 1955. Property damage generally begins when hail reaches three-quarters of an inch wide. A stone found in Kansas in September 1970 set the record at more than seven inches wide and 1.7 pounds.

HAIL: SHOWERS OF ICY STONES

Like fistfuls of marbles tossed by wind, hail pelts most of the continent at some time each year. Much of what falls in the Northwest is graupel, or small, soft hail. In the lee of the Rockies—from Alberta through the High Plains to Texas—hail falls fat and deadly, killing livestock and destroying crops, cars, and roofs with dismal regularity. Though the number of hailstorms has remained stable, property losses have soared. "We've made ourselves vulnerable to hail damage by increasing the size of the targets," says U.S. climatologist Stanley Changnon. As cities have blossomed in the hail belt, property losses have hit a par with those for crops—a combined total of some 2.3 billion dollars a year in the U.S. In Canada crop losses alone run 175 million dollars. Though rarely lethal, hail has killed eight people in the U.S. in the 1990s. In 1976, 12 died in Mexico City when a hail-weighted roof collapsed. Cloud-seeding efforts have had some success in suppressing hail.



With magnetic pull cities and their suburbs have drawn people from rural areas throughout this century. Showing the steepest rise, Mexican cities now house nearly 80 percent of the population, a slightly higher percentage than in the U.S. or Canada. Tightly packed, cities can be easy targets for natural calamity.

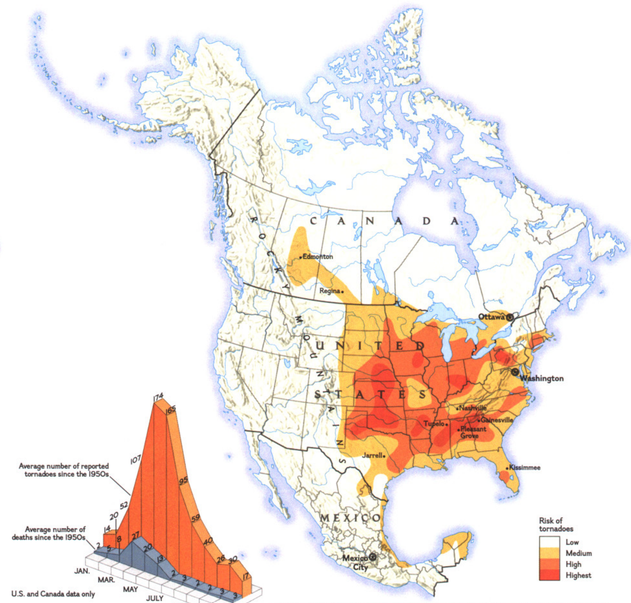
POPULATION: MOVING TOWARD TROUBLE

"A hazard only becomes a disaster when it occurs where people live," says NOAA meteorologist Joe Golden. Unfortunately, people are moving into harm's way at a fast clip. Mexico City has nearly 20 million people living in a region at risk from quakes and volcanoes. The U.S. South and West—prone to drought, fires, hurricanes, quakes, and mudslides—are expected to grow by 32 and 51 percent respectively by the year 2025. Half the U.S. population lives in coastal states, with some 34 million in Texas and Florida, two favorite hurricane targets. And three of Canada's largest cities—Montréal, Vancouver, and Ottawa—lie in seismically active zones. Do people worry? Not much. "There's a certain fatalism about disaster," says Mario Ordaz-Schroeder of Mexico's National Center for Disaster Prevention. Indeed, by desire or lack of choice people still build on volcanic slopes and barrier islands. Says NOAA's Golden, "We don't always learn from our mistakes."

Based on 250 years of historic records, the region has experienced 454 volcanic eruptions—391 of those in what is now the U.S. The apparent rise of occurrences in Alaska is due to better reporting. Though quieter in the 20th century than in the 19th, the Cascades could come to life any time.

VOLCANOES: DANGEROUS NEIGHBORS

Two thousand years. It's a blink in geologic time but hardly factors when planning where to build a home or plant a field. Perhaps it's time to reconsider. In Canada, Mexico, and the U.S., 91 volcanoes have been active within the past 2,000 years—74 in the U.S. alone, ranking it third in the world as a volcanic hot spot. Most occur above subduction zones, where ocean plates dive beneath the continent, creating chaos underground. Of particular concern: Mexico's Popocatépetl, which became active in 1994, threatens the 22 million people who live within 60 miles. In the Cascades, Mount Rainier looms steep, icy, and subject to debris flows that could reach Puget Sound. Geologists monitor young calderas such as Wyoming's Yellowstone and California's Long Valley, which have recently been showing seismic activity. Tougher to monitor but still hazardous are areas called monogenetic fields, where destructive cones like Mexico's Paricutin can rise suddenly.

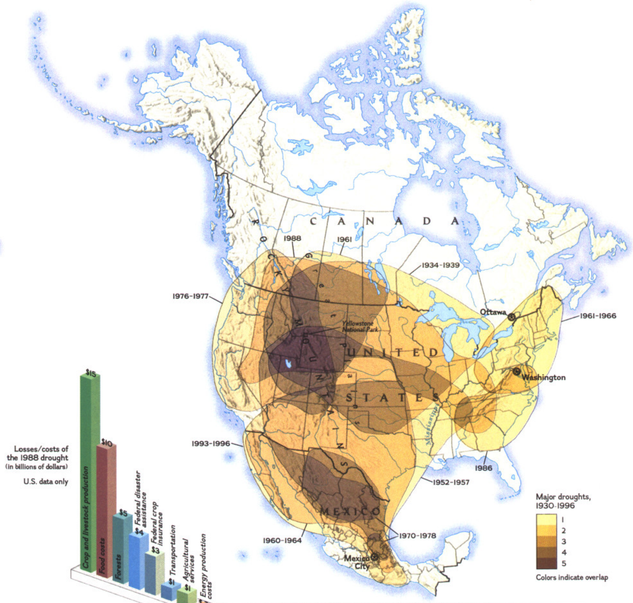


Favored turf for tornadoes, the U.S. and Canada have averaged 799 twisters and 90 deaths a year—the vast majority of both in the States. Most twisters hit the U.S. heartland from April through June. Canada's tornado season peaks later. Just 2 percent of tornadoes cause three-quarters of the deaths.

TORNADOES: TERRORS OF THE HEARTLAND

"You don't usually think weather is evil. But this was," said one survivor of a tornado that hit Jarrell, Texas, in 1997. From 800 to 1,100 tornadoes now scour the U.S. each year—more than in any other nation. Canada reports 50 to 160. Twisters find fertile spawning ground where humid winds from the Gulf of Mexico underlie swift dry westerlies from the Rocky Mountains. Texas, Oklahoma, and Kansas are hardest hit, but tornadoes have nicked every state, and sightings are up as population and cell phones proliferate. (Mexico does not track tornadoes.)

Twisters are ranked on the Fujita damage-intensity scale of F0 to F5. The vast majority of touchdowns do little harm and vanish quickly. Canada has never had an F5 storm; the U.S. has had many. With wind speeds topping 260 miles an hour, these monsters can wipe homes off the map and suck asphalt off streets. But even low-grade tornadoes—especially those that linger—can leave tragic scars.



The 1988 drought was the costliest natural disaster in U.S. history. Beyond losses to corn, wheat, and other crops, accounting for slightly less than half the 39.2-billion-dollar total, fires burned 12.6 million acres, hydroelectric power dipped, and Mississippi River traffic slowed to the tune of 220 million dollars.

DROUGHT: THE LAST GASP

Like an insidious plague, drought builds slower, spreads farther, lasts longer, and touches more lives than any other natural disaster. Roughly 10 percent of the continent experiences drought in any given year. Canada's Prairie Provinces, the western and central U.S., and north-central Mexico most frequently feel drought's grip, but all corners of the continent have suffered periods of water shortage.

Drought's impact ripples like heat off pavement. Crops die, food costs soar, livestock starve, water tables drop, fires rage, and heat takes human lives. Most infamous, the Dust Bowl of the 1930s withered crops from the Prairie Provinces through the Great Plains. Mexico's 1960-64 drought devastated the nation's cattle industry. A vicious 1988 drought left Yellowstone ablaze and caused from 5,000 to 10,000 heat-related deaths. Natural periods of low rain and growing competition for limited water supplies mean vulnerability to drought is on the rise.

For information about available maps call toll free 1-888-CALL-NGS or write to National Geographic Society, P.O. Box 11650, Des Moines, IA 50350-1650. You can reach us on the World Wide Web at **www.nationalgeographic.com**.

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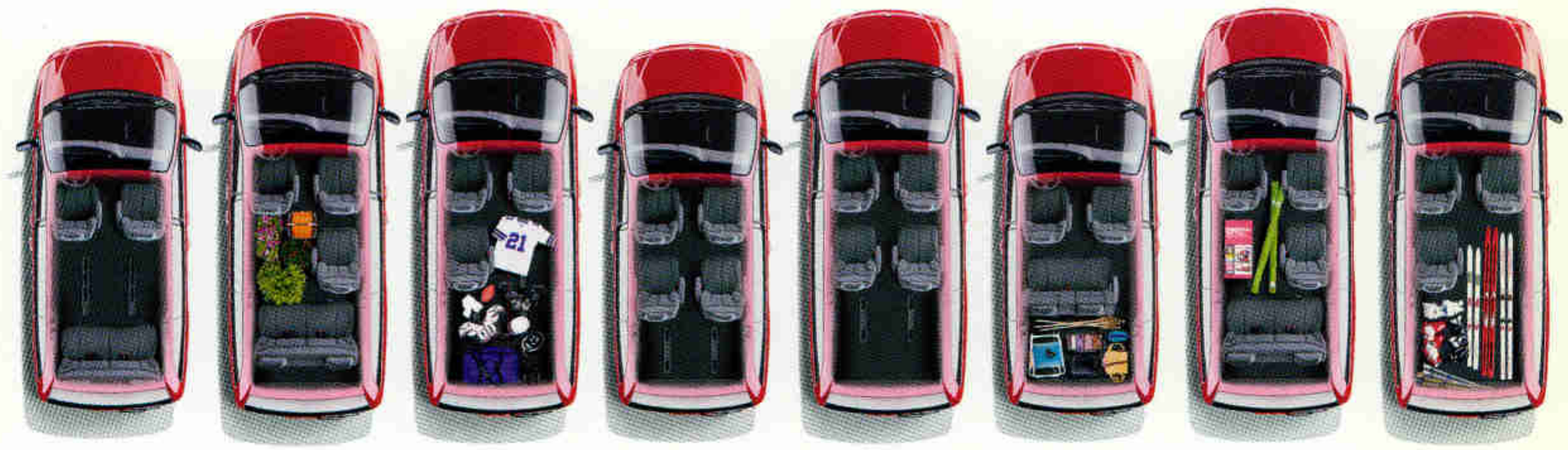

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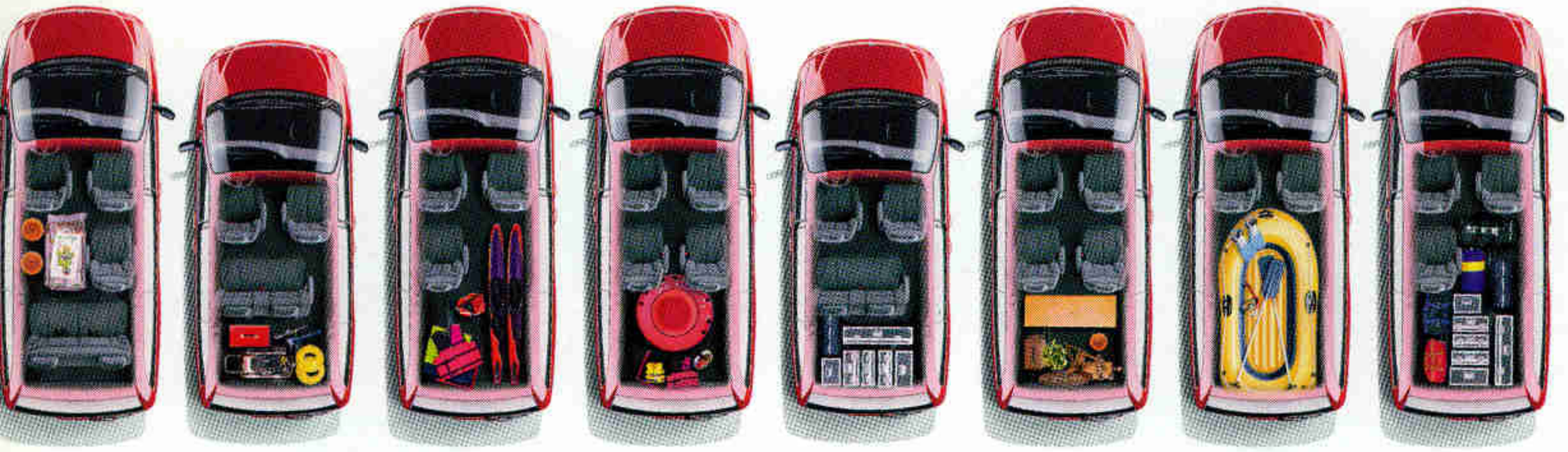

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your average Saturday. To learn more about this Automobile Magazine *1998 All-Star,*

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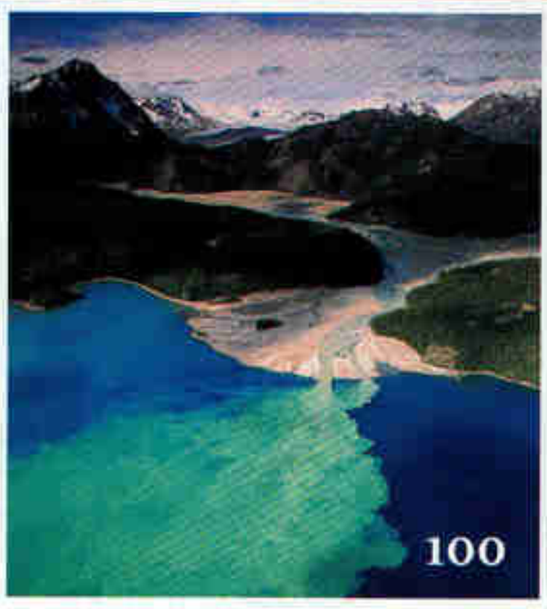

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2 **Living With Natural Hazards** *Ice storms, tornadoes, floods, wildfires—all exact a high price, yet more and more people are living where such disasters are most likely to strike.*
BY MICHAEL PARFIT PHOTOGRAPHS BY JIM RICHARDSON

■ *Double Map Supplement: Natural Hazards of North America*

40 **Lure of the Frogfish** *Thriving in warm water around the globe, the frogfish can change color, walk on its fins, and attract prey with wormlike "bait" that dangles from a spine on its head.*
ARTICLE AND PHOTOGRAPHS BY FRED BAVENDAM

50 **Civilized Denmark** *A clean and prosperous land with virtually no crime or poverty, the smallest country in Scandinavia is, according to an American humorist, "the World's Most Nearly Perfect Nation"—except in winter.*
BY GARRISON KEILLOR PHOTOGRAPHS BY SISSE BRIMBERG

74 **Dinosaurs Take Wing** *New fossil discoveries from China reveal astonishing feathered creatures that lived more than 120 million years ago and appear to confirm what scientists have long theorized: Birds are dinosaurs.*
BY JENNIFER ACKERMAN PHOTOGRAPHS BY O. LOUIS MAZZATENTA
ART BY PORTIA ROLLINGS MODELS BY BRIAN COOLEY

100 **The Untamed Yukon River** *A century ago tens of thousands of prospectors rafted its length dreaming of gold. Today North America's fifth largest river yields a mother lode of empty space to dreamers with an itch for challenge and elbowroom.*
BY MICHAEL PARFIT PHOTOGRAPHS BY JAY DICKMAN

128 **New Inca Mummies** *High in the Peruvian Andes archaeologists have uncovered the remains of four more human sacrifices, adding new insights into the complex spiritual life of an ancient people.*
ARTICLE AND PHOTOGRAPHS BY JOHAN REINHARD

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The Cover

Strutting out of the past, a feathered dinosaur, Caudipteryx zoui, *seems to cinch the case for a link between dinosaurs and birds. The 35-inch model, based on a fossil found in China, was created by Brian Cooley. Photograph by O. Louis Mazzatenta*

NATIONAL GEOGRAPHIC

Behind the Scenes

Getting Wrapped Up in Her Work

"I accept the honor of being the Society's explorer-in-residence," said Sylvia Earle, "as long as I can consider the sea my residence." The former chief scientist for the National Oceanic and Atmospheric Administration, here with a moray eel and a castaway moped off Grand Cayman, will work on books and a film during her year here; she will also dive at each of the 12 national marine sanctuaries. Exploring the sanctuaries is key, she says. "People can't protect places they don't know about."

DAVID DOUBILET

An Artist Wings It

Canadian sculptor Brian Cooley spent two and a half months, and countless partridge, pheasant, and rooster feathers, creating the fiberglass sculpture of *Caudipteryx zoui* featured on this month's cover. The flightless feathered dinosaur was such a new find, in fact, that Brian started work having little idea what his subject looked like. "I was already working on an armature for a feathered creature called *Protarchaeopteryx* when paleontologist Phil Currie called me about this new discovery. Luckily the two were about the same size, so I just lopped off the old head and wings and started over."

GARY CAMPBELL

Paws to Consider

Felines are the focus this summer when the exhibit "Cats! Wild to Mild" lands on its feet at our Explorers Hall. On the wild side—this Maya shaman figure is transformed, electronically, into a spotted cat as part of a display on the pre-Columbian cult of the jaguar. On the mild side—an interactive veterinarian's office will help visitors learn how to give better care to pets at home.

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DAVID FAIRCHILD (LEFT AND ABOVE)

Bugging Out With National Geographic Photographs

We've been giving you the creepy-crawlies for years. In our May 1913 issue David Fairchild's photographs make bugs seem to skitter right off the page. Trained as a botanist, Fairchild designed an expandable camera he called "Long Tom" to photograph insects in his Maryland backyard. He'd spend half an hour sweltering beneath black cloth to focus on each tiny, lifeless subject—like this longicorn beetle—that his wife had mounted on a leaf with paraffin. Fairchild's photographs were head-on at a time when most textbooks showed insects from above. He relished presenting "these monsters to the public as a showman might."

Fairchild, who helped establish Fairchild Tropical Garden in Coral Gables, Florida, first became interested in bugs through his small son. "He was hunting for them with the same enthusiasm that a big-game hunter stalks his game in the jungle," Fairchild recalled, "and the thought flashed into my mind, why shouldn't we hunt them with a camera."

MARK W. MOFFETT

ROGER LEGUEN

Mark Moffett has been doing just that for years. An insect aficionado since childhood, the Smithsonian researcher uses considerably less camera than Fairchild did and takes it to more exotic locales, including repeated visits to the New Guinea rain forest (above). Another difference: Mark doesn't kill his subjects, such as this leafcutter ant in Brazil (above left) from our July 1995 issue. "Unfortunately, plenty of natural history photographers still kill their subjects or chill them so they stop moving," he notes. "But would you kill a lion to photograph lion behavior? You can't learn much from a posed picture of a frozen ant." With Mark there's no such thing as the one that got away. "They all get away," he says, "after I get the picture."

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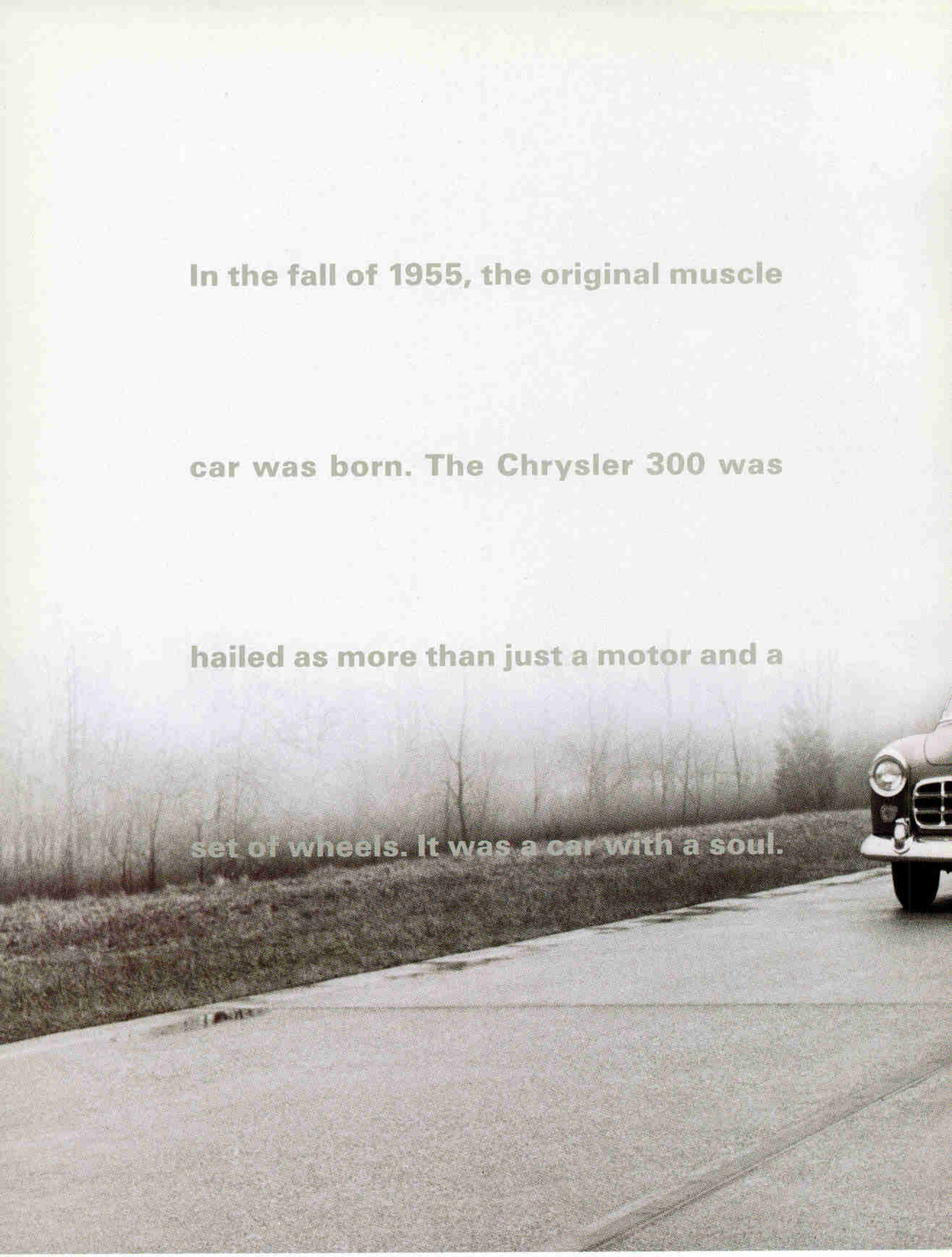
Introducing the all-new 1999 Chrysler 300M. The stance alone is defiant. But look beneath the skin of this vehicle and its real daring emerges. For starters, there's a remarkably light-weight, all-aluminum, high-output 3.5 liter engine, delivering a massive 253 horsepower. Valves? No less than twenty-four in an engine which is the most potent, naturally aspirated V6 motor in an American sedan today. Small wonder, then, that the new 300M can also boast being the most powerful

sports sedan in its class. High-performance anti-lock brakes and low-speed traction control provide optimum control during braking and accelerating, and the steering system is, of course, calibrated for maximum response. Complete everything with an aggressively tuned, fully independent suspension system coupled with seventeen-inch low-profile tires and one is left with a very clear impression: The new Chrysler 300M is a machine that is passionately created for driving enthusiasts.

From the outside, the all-new Chrysler 300M has the definite appearance of a sports sedan. But, once inside, you'll discover amenities usually only associated with luxury cars. Unlock the door by remote and the driver's seat automatically glides back for easier entry. You'll also find such anomalies as heated eight-way power seats co-existing with electroluminescent instrument-panel gauges that are all precision analog. And a premium nine-speaker CD/cassette sharing cabin space

with AutoStick®—a high-performance transmission feature that lets you switch out of automatic and then manually control gear changes up or down by simply flipping the stick left or right. Other luxuries include memory settings for the driver's seat, outside mirrors and radio—not just for one driver but two. And, naturally, there are leather-trimmed seats and luxurious "soft-touch" finishes throughout. The all-new 300M. It's an intelligent approach to sports sedan design.



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And a soul.

in history as America's original muscle car. In no time, it shattered the Flying Mile record at Daytona Beach. Equally breakthrough is today's 300M, a vehicle that is already critically acclaimed as one of those rare machines where engineering excellence translates immediately into driving excellence. Presenting the all-new Chrysler 300M. The technology has changed. But the soul lives on. For details, call 1.800.CHRYSLER or just visit www.chryslercars.com.

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Drawing on Their Past

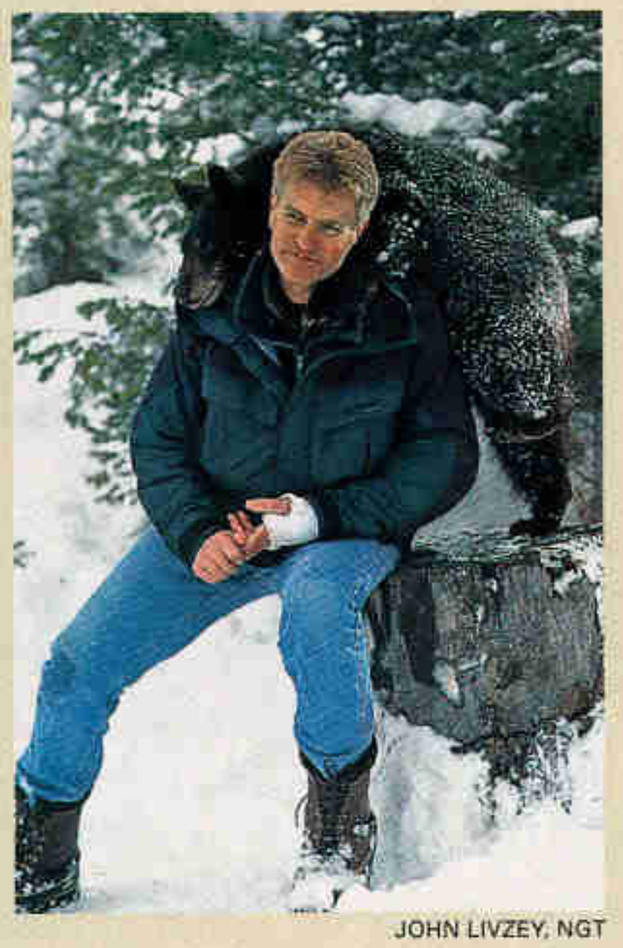
A little-known chapter of American history unfolds in a new Society book, *Warrior Artists*, by Herman J. Viola. In 1875, 74 Plains Indians—including two women and an eight-year-old girl—who had been linked to raids on white settlements were rounded up by U.S. Army troops and taken to Fort Sill in present-day Oklahoma. From there they were banished to St. Augustine, Florida, where, in an old Spanish fortress, the group was imprisoned for three years to ensure docility on the part of their people back home. Cavalry officer Richard Henry Pratt accompanied the Indians to Florida and took command of them once there. Sympathizing with their plight, he did his best to win their release. Art was part of his public relations plan; Pratt supplied the men with pencils and paper. Soon hundreds of drawings depicting traditional hunts (top) as well as life after capture were bought by prison visitors. Pratt's plan worked: The group was released in 1878. One bound sketchbook of drawings done by two prisoners—Making Medicine (above, seated at left), a Cheyenne, and Zotom, standing at right, a Kiowa—was given to Commissioner of Indian Affairs John Quincy Smith. His family has cherished the volume ever since; his descendants even came to our headquarters to guard their treasure while its fragile pages were being photographed for the new book.

OKLAHOMA HISTORICAL SOCIETY

TEXT BY MAGGIE ZACKOWITZ

Boyd Matson and His Bang-up Job

He has described his four years hosting our EXPLORER television series as a "dream job," taking him on distant adventures; he once ran a 140-mile footrace through the Sahara. But Boyd Matson just missed a nightmare last January—crashing his motorcycle soon after filming began for a show on a 650-mile motorcycle tour of Chile. The EXPLORER team, which included singer Lyle Lovett, continued without him. Boyd spent the night in a hospital with a dislocated elbow but soon rallied; ten days later he was back at work, sharing screen time with a trained black bear in Montana.



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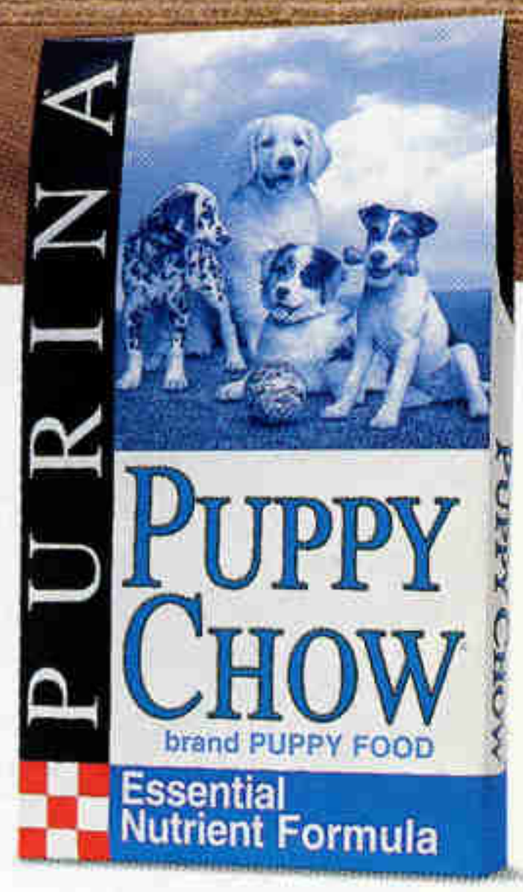

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Forum

Both the Editor's page and "The Rise of Life on Earth" in the March 1998 issue dealt with evolution, a controversial subject for some members. Readers divided between those who look to the Bible for scientific explanations and those who consider evolution a given. Some agreed with the Texan who wrote: "Evolution seems like proof of God to me."

From the Editor

I accept your editorial as characteristic of your striving for completeness, balance, and scientific soundness. I must take exception to an unintended conclusion some may draw from your saying that scientists have no business questioning the existence of God, namely that they have no business questioning any religious belief. Yet some beliefs and judgments have the power to set entire peoples against each other. Do I not have a right to identify and correct harmful error?

PHILLIP A. M. HAWLEY
Paonia, Colorado

As a Christian and an engineer, I am fascinated by scientific studies into early life. Increasingly my faith is bolstered by scientific discovery.

RICHARD RHIMES
Somerville, Australia

If every article on evolution attracts two piles of letters, one appreciating the insights and the other—from readers of the Bible as a science text—rejecting them, add this letter to the former pile.

REV. PETER DAVIDSON
Theodore, Australia

The Rise of Life on Earth

Bravo to the GEOGRAPHIC and author Richard Monastersky for an outstanding article. I encourage you to continue such "explorations," especially those that shed light on the greatest and most misunderstood frontier of all—the understanding of ourselves, of why and how we think and behave the way we do.

JAMES T. BROUS
Shawnee Mission, Kansas

I find it hard to comprehend, after your definition of science on the Editor's page as the study of testable and observable phenomena, why your writers would use so many qualifiers, such as may have been, could have, probably, perhaps, puzzling, likely, and other terms that indicate so much doubt.

Faith is not blind just because it involves the unseen. It is affected by what we see, hear, and touch. Basic logic tells us that every house declares a builder.

TOM YATES
Spring, Texas

Conceding the fact that the agent of the origin of life on Earth is unprovable either by creationists or scientists, we are forced to arrive at a conclusion in the light of probabilities. Since there is no evidence that anything supernatural either exists or has ever existed, it is totally illogical to accept a theory based on such a belief. Conversely the very real evidence of the fossil record and the recent discoveries in molecular biology are there for all to see.

LEO WOODROW
Alicante, Spain

When I taught college science foundation classes, I found that one of the students' major misconceptions of evolution was the mechanics of mutation and its description in the English language. When an organism is mutated (changed), the mutation occurs because an outside agent or event—ultraviolet rays, an error in duplicating DNA—affects cellular reproduction, changing the basic cell of the organism. The organism does not consciously decide to mutate; it is a passive partner. Students are confused when active voice is used to describe mutation. Wording like "the giraffe mutated" causes students to think it decided to grow a longer neck. Not so.

EDNA WHITTIER
Holt, Michigan

National Marine Sanctuaries

When the author says he could smell the 11,000 cesspits in the Florida Keys, I think he misinterpreted the rotting sea grass smell on the shore. It is very similar, but I would have to stand downwind very close to a single cesspit to smell it. We in the keys know we need waste treatment. To build a sewage system, we must tear up 95 percent of the roads, streets, and lanes and parts of U.S. 1, our only artery in and out. The expense will be staggering, but we will do it eventually.

GERARD WATERS
Key West, Florida

As a marine geologist with the U.S. Geological Survey, I would like to add that we have been working with some sanctuary managers to map seafloor geology and habitats, using new ship-based mapping technology. The spectacular high-resolution maps, CD-ROMs, and other products give new information on the evolution of these regions and show the importance of seafloor geology and marine processes in maintaining these marine ecosystems. I invite readers to the Coastal and Marine Geology website at *http://marine.usgs.gov.*

S. JEFFRESS WILLIAMS
Reston, Virginia

The phrases "commercial fishing" and "marine sanctuaries" seem incompatible, yet the first is


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TO: ALL
FROM: FRANCISCO JAVIER BERTAUD

We just spent the morning building nesting cavities for ducks. And yesterday we planted wildflowers and a new species of cactus.

That may seem a little unusual for someone who works for a Ford assembly plant but you see, I'm the official biologist. Our facility in Cuautitlan, Mexico is home to lots of wild geese, falcons, lizards, and shrikes.

Our team of 15 people works full time to preserve and enhance the wetlands and wildlife in our 260-acre compound. A few feet from where our coworkers build F-series trucks, we're planting thousands of trees and the hummingbirds are laying eggs.

I have a nice job, don't you think?

FRANCISCO JAVIER BERTAUD

allowed inside the latter. That doesn't sound correct if a marine sanctuary is actually a sanctuary.

TED LA FORE
Honolulu, Hawaii

Naples Unabashed

During a visit to Naples last year my companions and I stayed in the Spaccanapoli section of this vibrant city. We found Neapolitans to be quite watchful over us. They gave directions without hesitation, made sure we got on the correct bus, and let us know when to transfer. They were careful to count out our change from a purchase so that we would not feel shorted. It was as if we were part of some extended family to them.

JOHN OLOW
Woodbine, Maryland

Little mention was made of the solid middle and upper class of Neapolitan professionals, who with no links to either corrupt politics or the Camorra bring forward day by day the huge civil, cultural, professional, and artistic heritage that the city has accumulated for hundreds of years.

TOMMASO RESTAINO
Naples, Italy

Planet of the Beetles

I was delighted with your photograph of mating ladybugs (pages 104-105). It reminded me of the time I found about 150 of the happy little beetles in my swimming pool. I rescued the shameless swingers and spread them on my garden. I took care not to disturb their larval cases and was rewarded by aphid-free plants for years.

SCOTT CAMPBELL
Vancouver, British Columbia

Alas, neither your beetles nor ours were mating, an activity they accomplish on land and normally not while in such aggregations.

Not to worry, the tortoise beetle and brood (pages 107-108) are safe because those are vegetarian ants going by. They use their powerful mandibles to cut leaves, flowers, and twigs. They are going elsewhere for their food. Great picture.

PETER WEBER
Swarthmore, Pennsylvania

Kudos to author Douglas Chadwick, who enhances the March issue with two articles. He gives us an appreciation for the diversity of life. Beetles rise like genies off the surface of his prose. And then he dives below the surface of the language for life's protean shapes within the sea in marine sanctuaries. May he continue writing for us.

STAN RENFRO
Fort Wingate, New Mexico

America's First Highway

In New Mexico we are commemorating the laying out of the route and way stations of the Camino Real de Tierra Adentro by Juan de Oñate and Spanish settlers in 1598. The route closely followed

Native American trails between Mexico and our Southwest. Settlers, goods, livestock, technology, ideas, and culture flowed up and down the Royal Road, creating the basic elements of the American West as we know it. The Royal Road remains "America's First Highway."

FRANK ORTIZ
Santa Fe, New Mexico

I was born and raised near the banks of the Ohio and have yet to see a barge pushing anything. The common phrase for a pusher like the one described on page 90 is a towboat. The huge bins lashed together with steel cables are the barges.

LLOYD EDWARDS
Toney, Alabama

Melissa Farlow's photograph of Cumberland, Maryland, captured the essence of the place (pages 92-3)—a city of hills, bridges, trains, and church steeples. More than that, she captured the Cumberland of my childhood. In the 1950s our family traveled twice a year from New York City to the home of my grandparents, aunts, uncles, and cousins. In my grandfather's musty sunporch, two blocks from the scene in the photo, he kept GEOGRAPHICS dating back to the 1920s. I spent many hours exploring a world I could only imagine. Now this photo recalls a place and time just as impossible to visit. My grandfather would have appreciated the irony.

MICHAEL W. ROHRER
Lincoln, Virginia

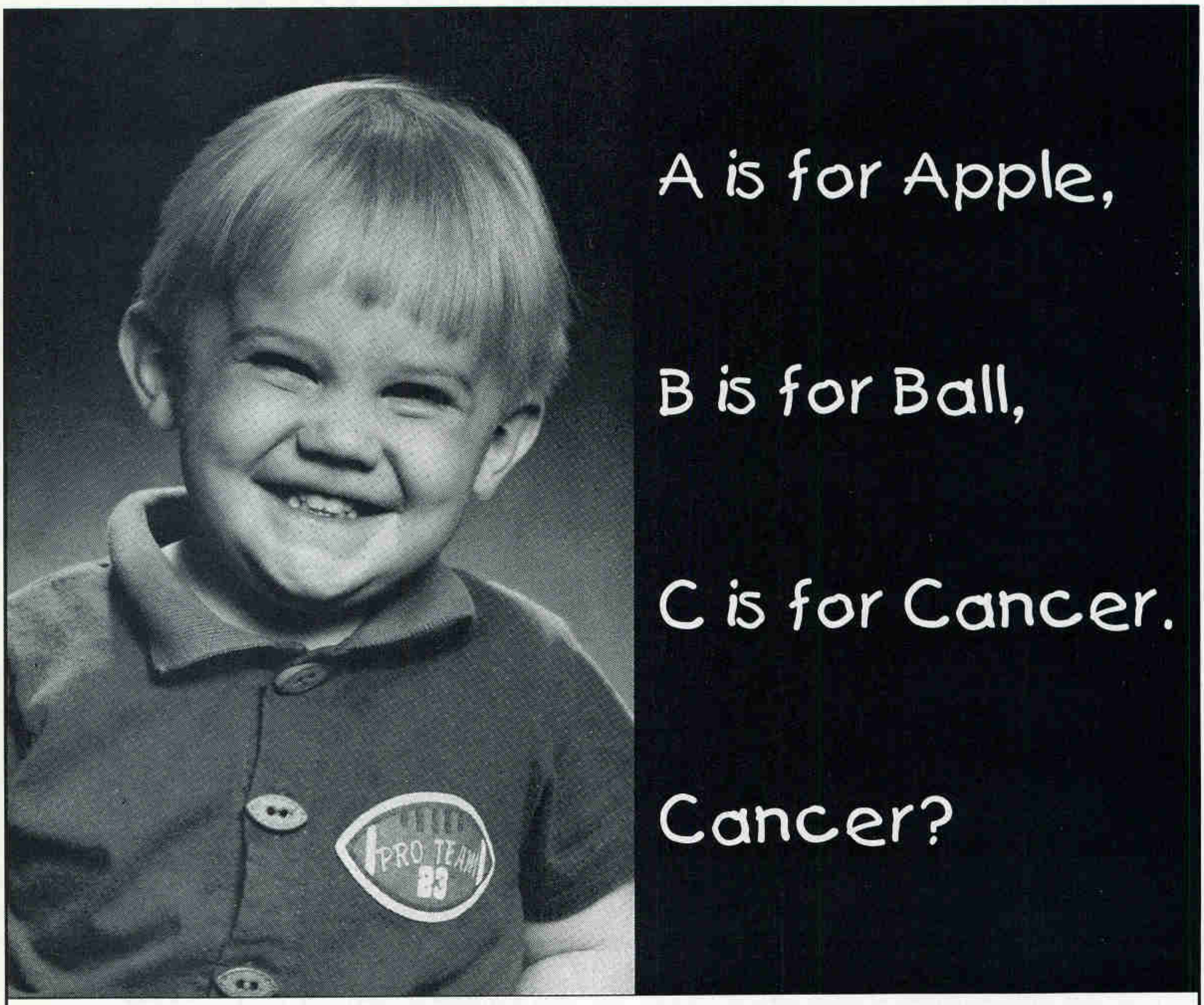
Crediting a Footprint

Regarding the photograph of the footprint on the moon from Apollo 11 in the February 1998 article "Why Explore?"—it was actually taken by me.

BUZZ ALDRIN
Laguna Beach, California

When the photograph was first published in our December 1969 issue and elsewhere, it was credited by NASA to Neil A. Armstrong, who took most of the still pictures on that first moonwalk. However, according to a 1987 NASA review, Armstrong passed the camera to Aldrin to take shots of boot prints for study of soil mechanics. We regret the error.

Letters for Forum should be sent to National Geographic Magazine, Box 98198, Washington, D.C. 20090-8198, or by fax to 202-828-5460, or via the Internet to ngsforum@nationalgeographic.com. Include name, address, and daytime telephone. Letters may be edited for clarity and space.



Each year, more than 6,000 children like Adam learn all about cancer and other catastrophic illnesses when they're stricken with deadly diseases. Fortunately, these children have a fighting chance at surviving cancer — the No. 1 killer disease of children — because of strides St. Jude doctors and scientists are making every day in treatment and research. With your support, St. Jude Children's Research Hospital is helping children all over the world live.

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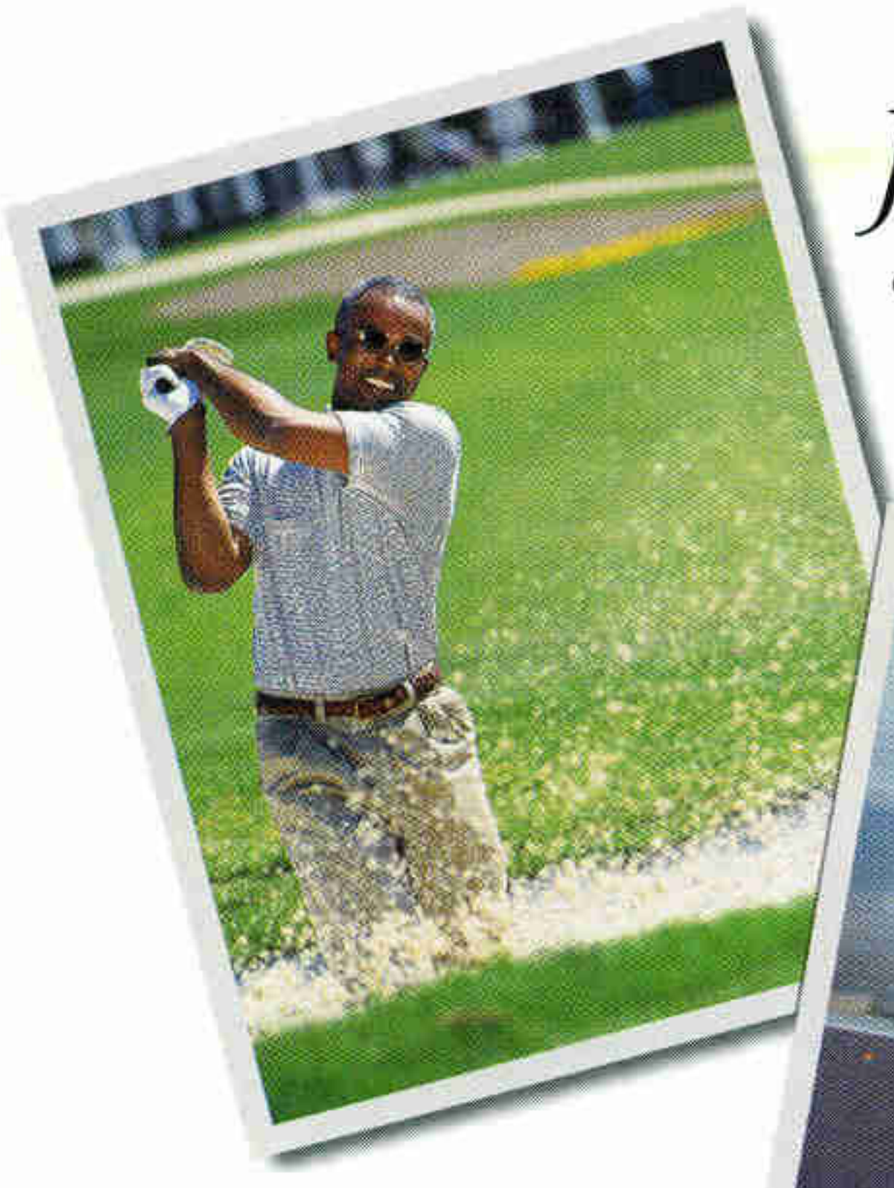
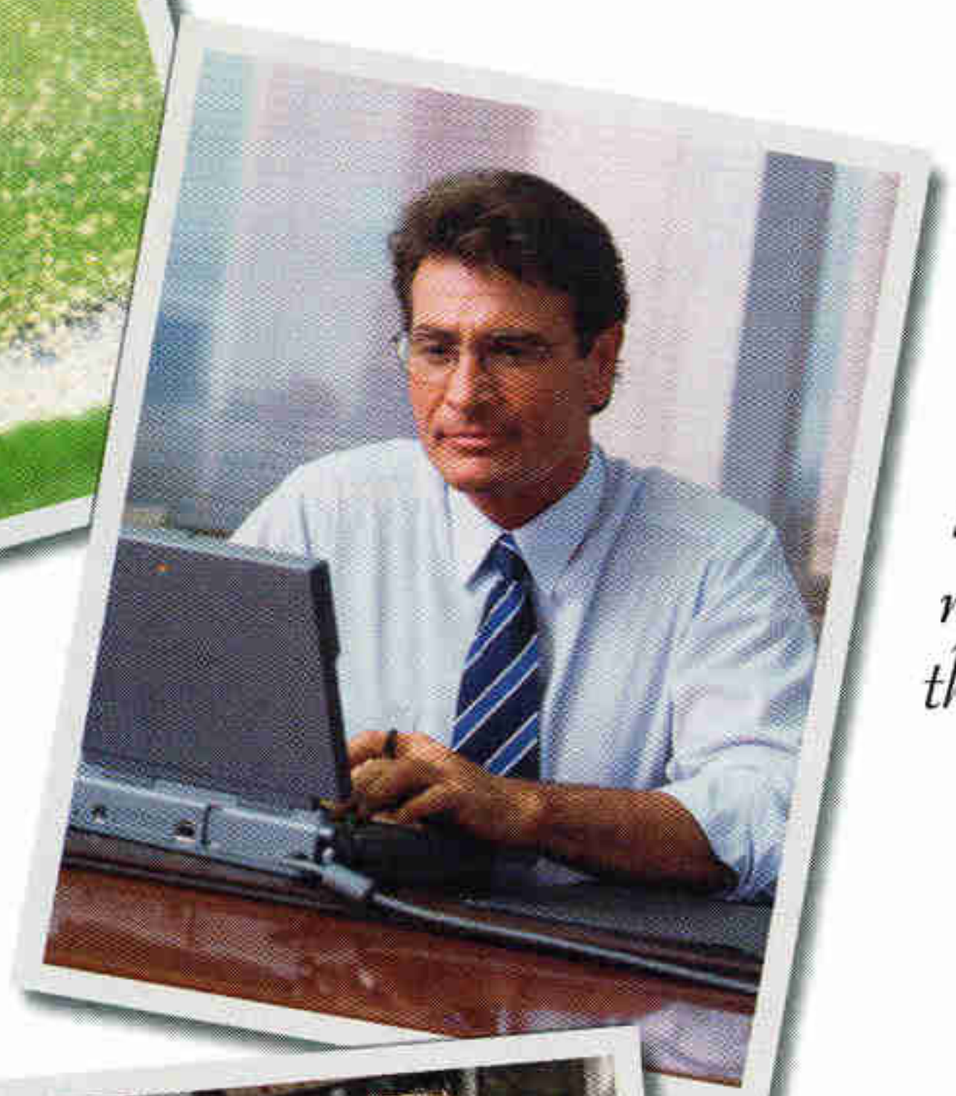


Jeff Wood, father of three and weekend pro, made the change last year.



George Evans, successful stockbroker, made the analysis, then made the change.

Richard and Tina Runyan made the change, before they made the big move.

Mrs. Debbie Minnis, juggler of house, kids and career made the change, to make life easier.

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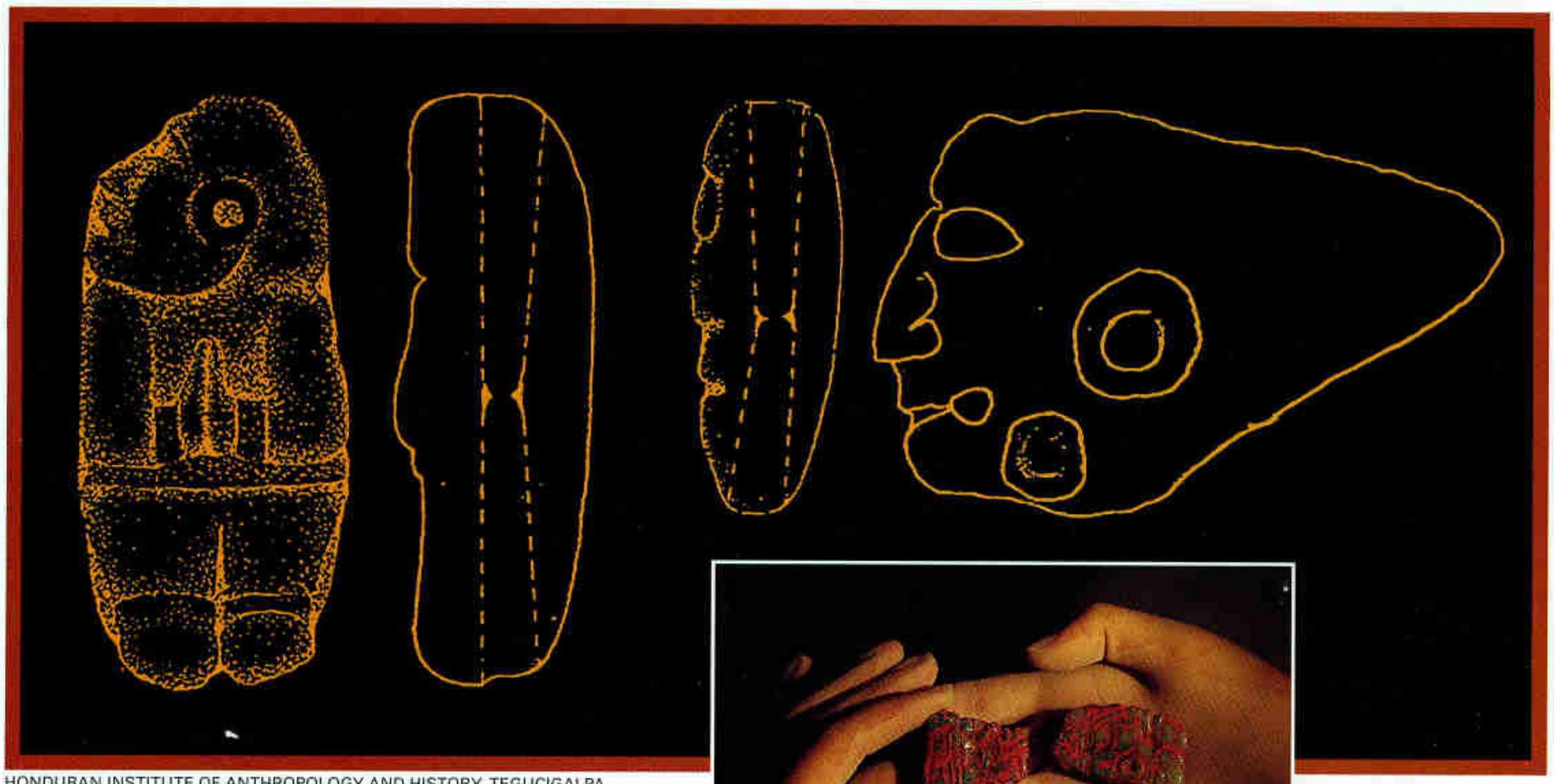


HONDURAN INSTITUTE OF ANTHROPOLOGY AND HISTORY, TEGUCIGALPA

Thieves Invade, Loot a Major Tomb at Copán

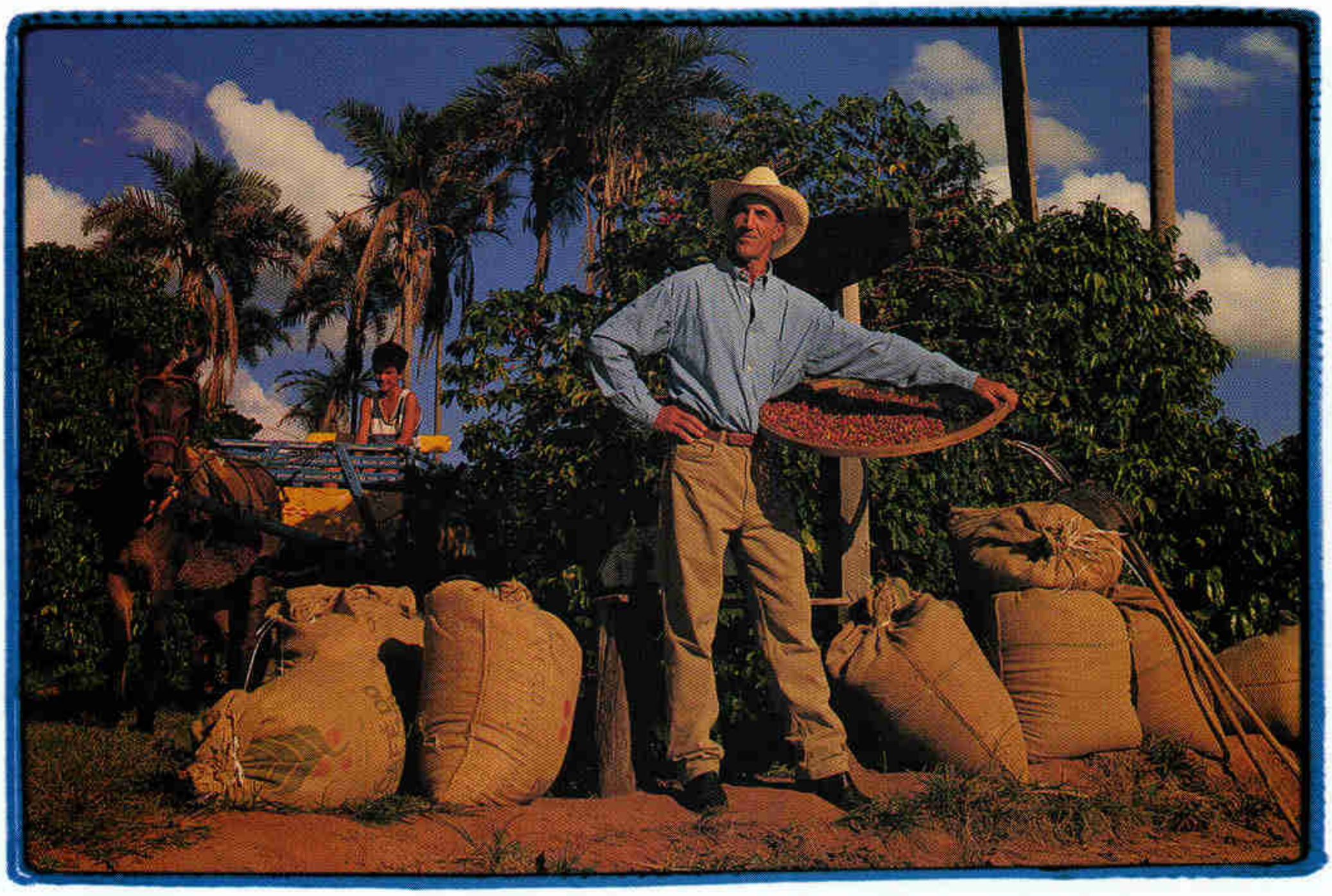
The looters forced open two doors and wound through a maze of tunnels to reach the burial chamber of a Maya woman, likely the wife of the founder of the Copán dynasty (GEOGRAPHIC, December 1997). They scooped up at least five jade ornamental figures and some 2,000 jade and shell beads from the Margarita tomb, retraced their steps, and fled.

The February 27 nighttime theft shook archaeologists and officials in Honduras. "This is an assault on our cultural and historical roots," says archaeologist Ricardo Agurcia Fasquelle, who directs the Copán Association. In a tragic aftermath the site's security chief, Miguel Angel González, who had worked at Copán for 35 years, committed suicide.

Police think only one or two looters took part, says Olga Joya, head of the Honduran Institute of Anthropology and History. "They had to know exactly where the tomb was," she adds. "They weren't in there very long." Archaeologists had already removed most of the woman's cinnabar-encrusted remains (below) and half the figures from her burial necklace (above). But they had only made sketches of the other figures, including two shown here (top) in front and lateral views.

For more about Copán visit our website: www.nationalgeographic.com.

KENNETH GARRETT (ABOVE AND INSET)



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Shining New Light on a Timely Problem

Jet-lagged? Switching to a night shift? Having trouble sleeping? Try shining light on the back of your knees.

Since 1986 scientists have known that shining light into a person's eyes readjusts the body's circadian rhythm, its body clock (GEOGRAPHIC, December 1987). Now research shows that applying light on the area behind the knees (right) works just as well.

"We were looking for a site far from the eyes with blood vessels near the surface," says Scott Campbell of Cornell University Medical College. He believes the light sends a message to the brain via the blood flow.

Campbell and his team invited subjects to live in their lab for a four-day period. The first day they charted the time the body began to produce the hormone melatonin, usually in the evening, and the body's lowest temperature, usually shortly before dawn. The next day the researchers administered light behind the knees. When they checked the onset of melatonin production and temperature 48 hours later, they found that body clocks had shifted up to three hours, depending on when and for how long light was applied.

There's no magic to the knees. "We could have used the inside of the elbows," Campbell says. Preliminary tests show he's right.

CHRISTOPHER RIMMER (LOWER LEFT); MARK THIESSEN, NGS (BELOW); BROOKS WALKER

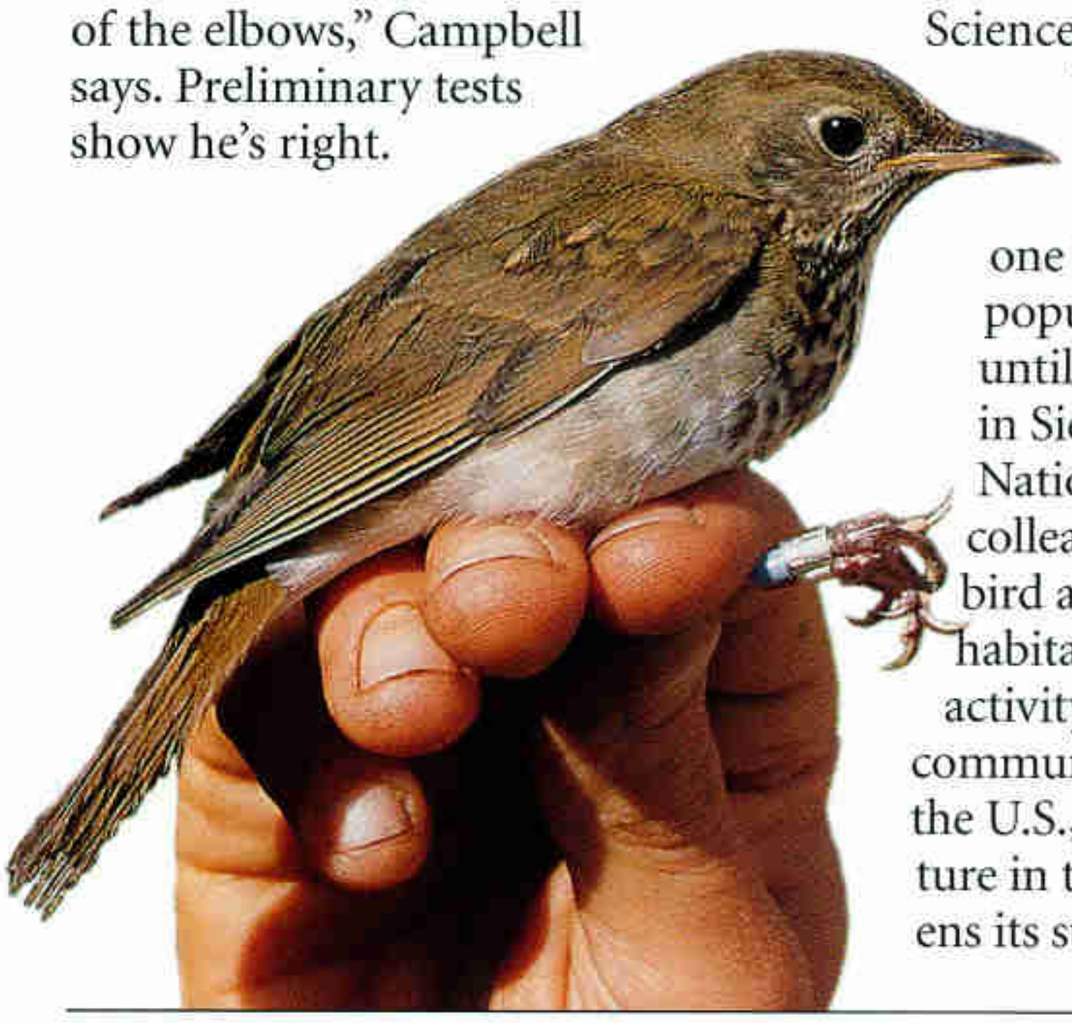
■ NGS RESEARCH GRANT

A Bird in the Hand Links Distant Homes

The Bicknell's thrush was like an old friend. Working in the Dominican Republic, Christopher Rimmer netted a bird like this one (below) and recognized from its band number that he had captured it the previous summer—on Mount Mansfield in Vermont, 2,000 miles away.

"It's nothing short of remarkable to band a bird on its summer breeding grounds and recover it on its wintering grounds," says the Vermont Institute of Natural Science ornithologist.

Thrushes head for the Caribbean each fall, but no one knew where specific populations wintered until Rimmer's work in Sierra de Baoruco National Park. He and his colleagues are studying the bird and its mountainous habitat to learn if human activity—ski resorts and communications towers in the U.S., logging and agriculture in the islands—threatens its survival.



A New Nation Adopts Its Own Currency

It took 30 years for Eritrea's rebels to win their freedom from Ethiopia

(GEOGRAPHIC, June 1996). Now Eritreans have traded in the Ethiopian birr, which continued to serve as legal tender even after independence in 1993, for the nakfa, named for a northern Eritrean town, a rebel stronghold.

Featuring the faces of women from various ethnic groups within the England-size nation, nakfa notes reflect its diversity. Eritrean Ambassador to the U.S. Semere Russom calls the creation of new currency "an economic and financial issue, not an emotional one. An independent nation with its own policies needs its own currency to implement economic decisions."

TEXT BY BORIS WEINTRAUB

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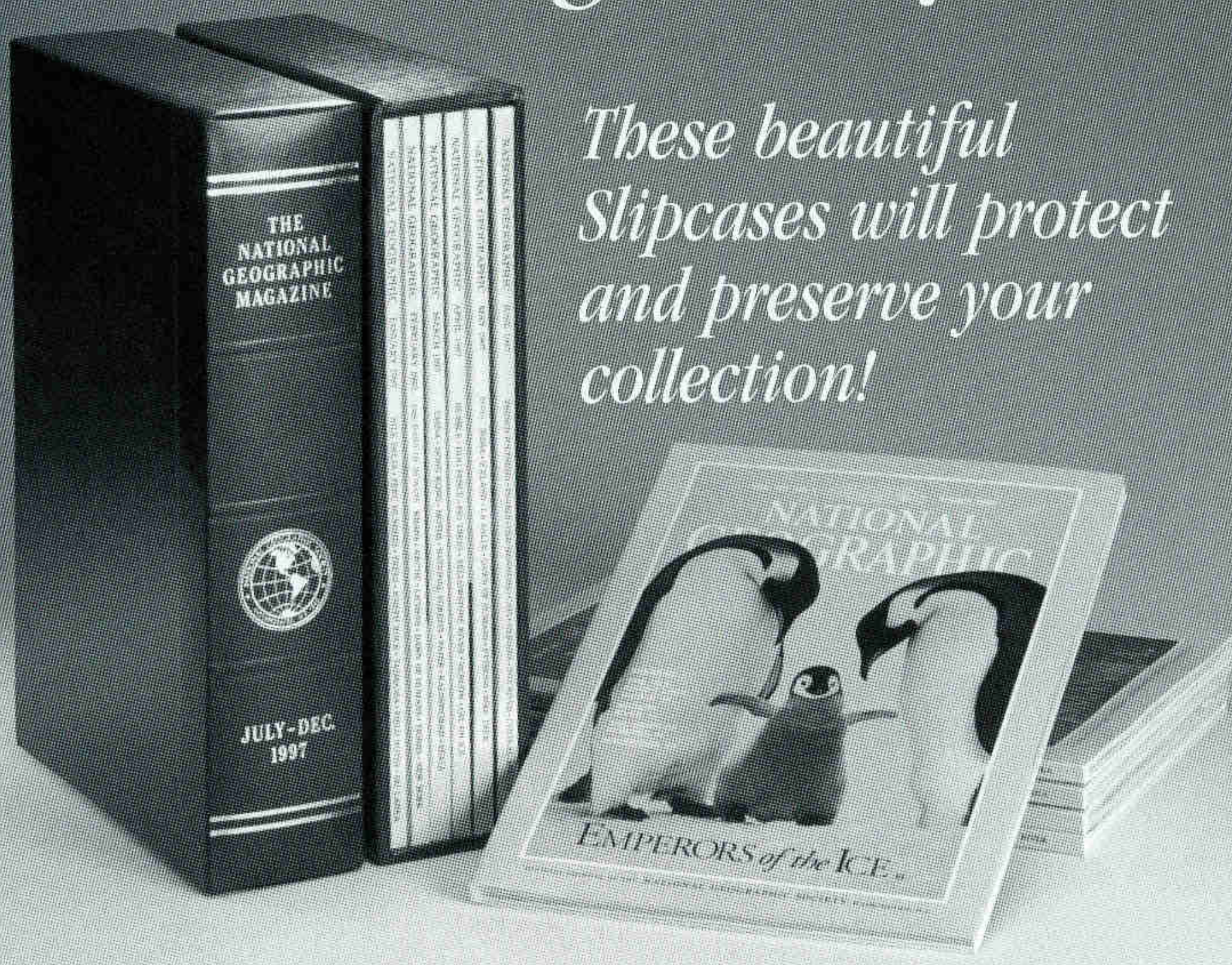

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Chevy Venture was ranked Most Appealing Minivan by J.D. Power and Associates in the 1997 APEAL Study.

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Chevy Venture

Let's Go!

*J.D. Power and Associates 1997 APEAL Study, Automotive Performance, Execution and Layout Study.℠ Study based on a total of 29,817 consumer responses. ©1997 GM Corp. Buckle up, America!

NATIONAL GEOGRAPHIC

From the Editor

I GUESS we'll have to face the fact that humans are, by nature, daredevils. For proof take a look at the natural hazards map supplement in this issue. The map is the result of a three-year, three-nation effort to collect and graphically present the natural perils that bedevil North America. Scientists from Canada, the United States, and Mexico shared information on hurricanes, earthquakes, tornadoes, floods, droughts, tsunamis, volcanoes, winter storms, hailstorms, wildfires, and landslides. And when the data are overlaid with population numbers, we find a tendency for people to put themselves in harm's way in exchange for a splendid climate, a gorgeous view, a central location.

A JANUARY 1998 STORM LOCKS CARS IN ICE AND CRUSHES TRANSMISSION TOWERS IN QUEBEC PROVINCE. PIERRE PAUL POULIN, SYGMA (TOP); RYAN REMIORZ, CANAPRESS

"Look at Los Angeles and Mexico City and Vancouver with their earthquake risk, or Miami and Galveston with their hurricanes," says Chris Tucker of Emergency Preparedness Canada, the project coordinator. "People don't think about how or where they build. They just ignore the natural hazards."

As they compiled their mountains of statistics, Tucker and his team always considered the GEOGRAPHIC the ideal place to present them. They approached us with the idea, and we went to work melding our maps and their data. The Reinsurance Association of America, which knows a thing or two about the effects of natural hazards, says the resulting map is the most comprehensive it has ever seen. Researchers will pore over the information for years to come. And at a glance we can appreciate humankind's adaptability—and curious penchant for living on the edge.

Bill Allen

Living With Natural Hazards

A seismic jolt in 1989 turned unstable fill under San Francisco's Marina district to liquid earth. Buildings collapsed, fires raged, people died. Natural cataclysms in North America threaten lives, homes, and peace of mind as never before.

By MICHAEL PARFIT

Photographs by JIM RICHARDSON

RORY LYSAGHT, GAMMA-LIAISON

BLIZZARD When white erases the world

BILL ALKOFER, *ST. PAUL PIONEER PRESS*

FIERCE WINDS, FRIGID AIR, AND 20-FOOT

drifts stalled 82-year-old Irene DeVos on a trudge to her mailbox in rural Minnesota in 1997. Heavy snows nearly buried DeVos's home. "I hope it never happens again," she says—a universal sentiment among survivors of nature's wrath.

TORNADO The frightful force of air

"MOMMY, WHY DID GOD DO THIS?"

Six-year-old Angel Cranmer asked a tough one after a tornado in Kissimmee, Florida, ripped roofs off homes in her Lakeside Estates neighborhood. At least seven twisters scoured central Florida last February, killing 42, most of them in trailer homes, the state's worst tornado outbreak in history.

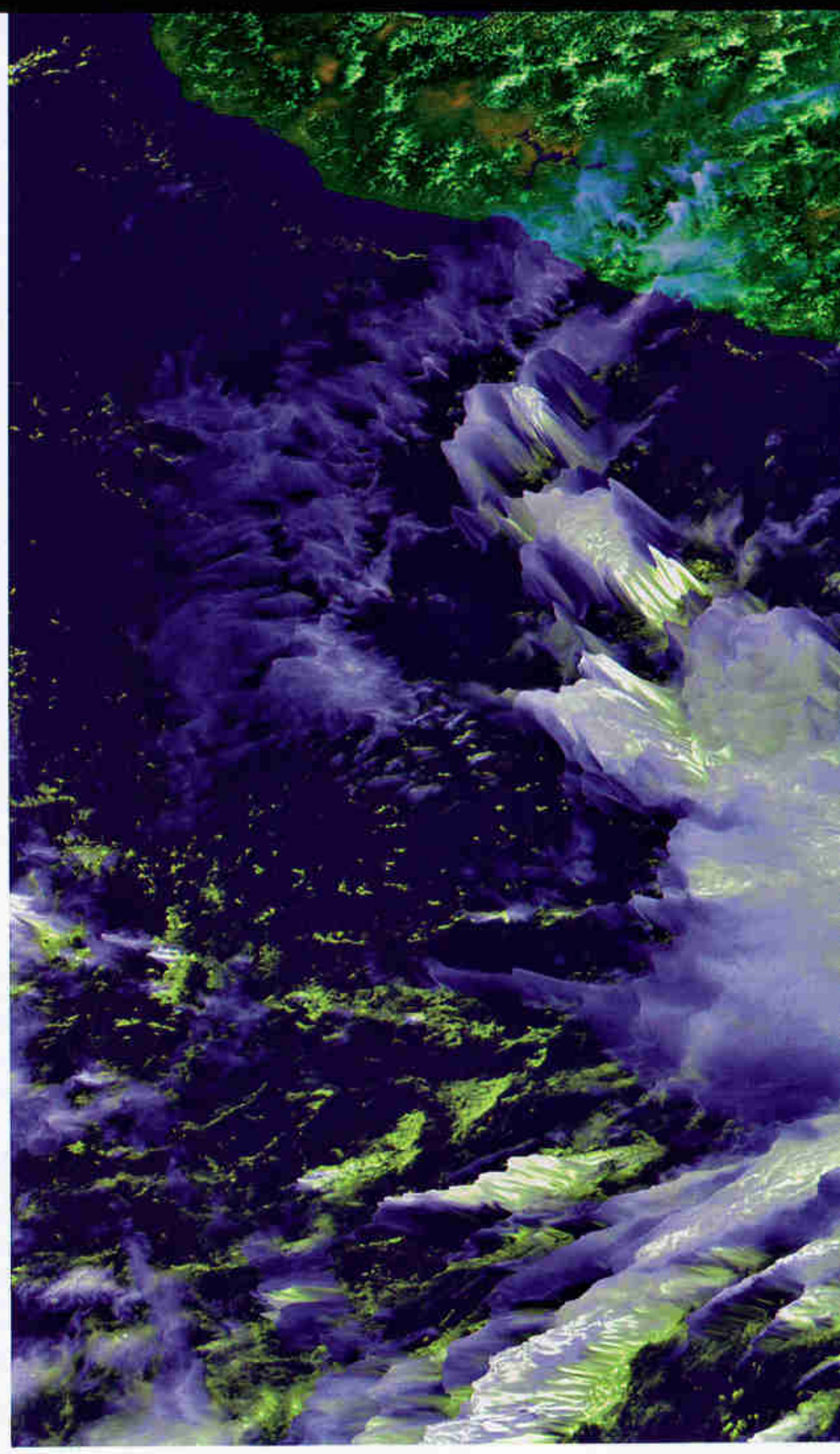
RED HUBER, *ORLANDO SENTINEL*/SYGMA

FLOOD Facing a rage of water

A TEXAS STREET BECOMES A TORRENT as the rain-swollen San Jacinto River forces Tannie and Frances Shannon to flee with their infant granddaughter and family dog. "It's hard to start over," says Tannie, his home ruined by the 1994 flood, "but life has taken on new meaning."

DAVID LEESON, *DALLAS MORNING NEWS*

ON THE STREET *of the Lost Child in the poverty-strewn suburbs above the Mexican resort city of Acapulco, Hurricane Pauline hits about 3:00 a.m. Its wind is blunted by the high hills, but the rain roars. By 4:00 the gullies sound like trains. By 4:30 water rushes across the floor of the home of María Micaela Alcaraz de Castillo. By 5:30 she, her husband, and their four children are groping through a thunderous darkness inside the house, water surging to their chests. "Roberto! María! Alberto! Imelda! Are you there?" They must get out. But how?*



A COLUMN OF CHURNING DARKNESS *moves slowly across a field near Jarrell, Texas. Paul and Joan Warhurst race toward the tornado in their van, but a patrolman blocks their way.*

"You can't go in there," he says.

"But my kids are there!" Joan yells.

They turn around and race down a back road, heading toward their house from another direction. Wind and debris lash the side of the van. The van's going 70, but Joan thinks she could run faster.

"Where's our house?" Joan shouts. Paul points at the churning blackness ahead and accelerates.

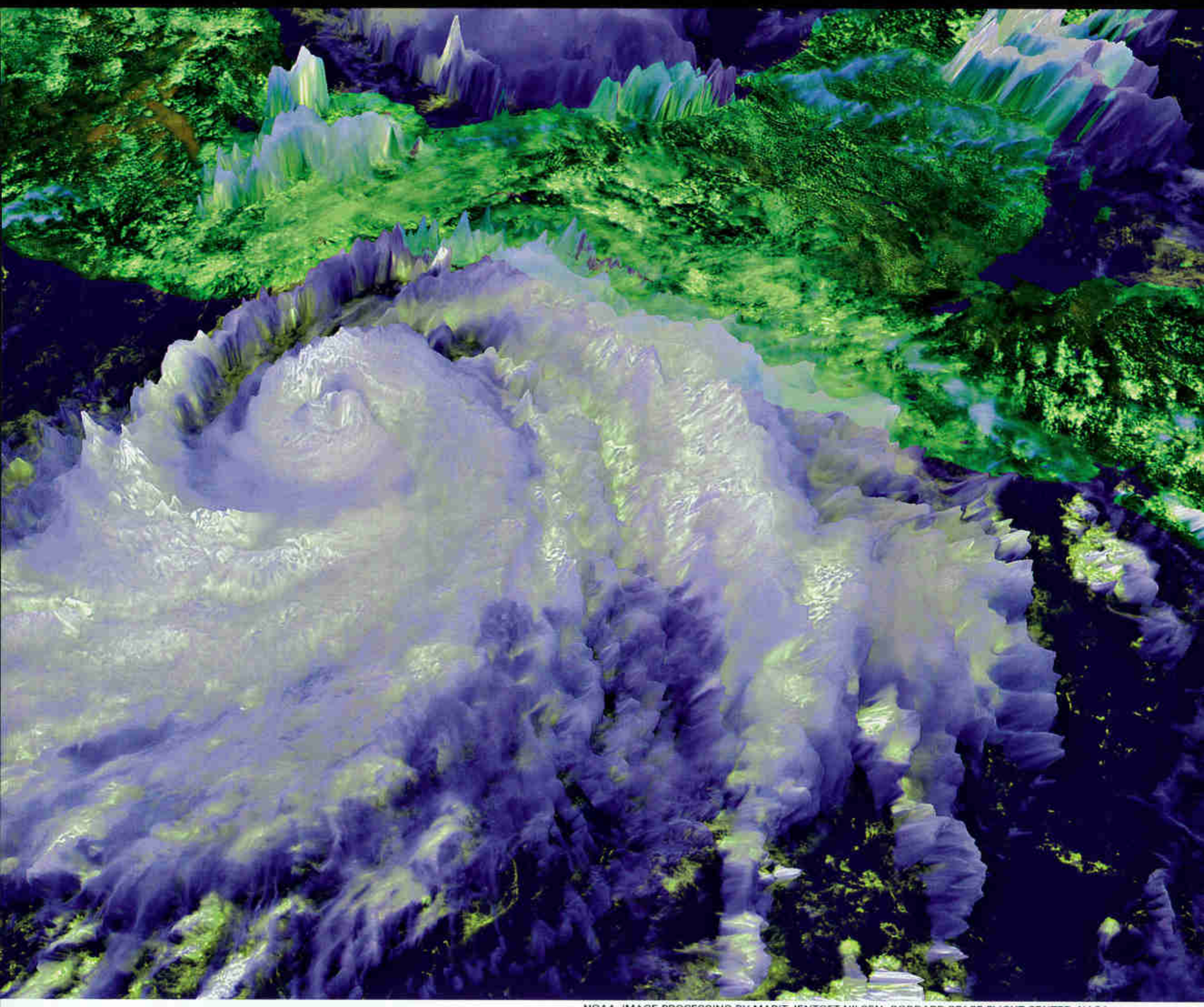
IN A TINY APARTMENT *near Northridge, California, Sander Halet is sleeping on the couch. He is 19, a southern California Valley Boy living on his own for the first time. "I'm working three jobs," he says later, "going to school, just, like, not knowing anything about life."*

Life is about to educate him, big time.

He wakes with stuff falling on his face. The sky? A nightmare? Plaster. The ceiling. Earthquake.

He sits up. The apartment is shaking violently. A water main bursts. Rafters groan. "You hear the building make sounds you never heard a building make before," he says later. "You, like, get detached from your body. You're not yourself. You're operating at a completely different level. It's instinctive. It's primal."

MICHAEL PARFIT, a frequent contributor, last wrote about the creation of Canada's newest territory, Nunavut, in the September 1997 issue. Although photographer JIM RICHARDSON has spent most of his life on the High Plains, he has never seen a tornado.



NOAA; IMAGE PROCESSING BY MARIT JENTOFT-NILSEN, GODDARD SPACE FLIGHT CENTER, NASA

FUELED BY WARM WATERS, Hurricane Pauline veers toward Mexico. The October 1997 storm was vicious more for its rain than for its wind. Dropping 16 inches on Acapulco, it bred mudslides and floods that left hundreds dead and thousands homeless.

PRIMAL MOMENTS are not common in human life. Much of our energy, our genius, and our accumulated knowledge is spent warding them off. But every once in a while the Earth reminds us that security is a facade. The very things that make life possible—the dynamic atmosphere, the shifting crust underfoot, the miracle of fire, the restless fluid rock of the depths, the war of heat and cold—can also disrupt and destroy life. In these primal moments human beings, terrified and awed at how powerful the Earth really is, find their lives stripped to fundamentals.

In literature, myth, and history, humans remember these moments—the survival of Noah, the anguish of Job, the terror of Vesuvius, the echo of Krakatau. We are compelled by the grandeur, the terror, the drama, the way lives are reduced to their simplest truths.

Like death, disaster repels and fascinates us. We stare at the hurricane pictures, we drive past the fire zone, we look in awe at the collapsed freeway, and we wonder: What if I were the one standing in the rubble of my home? How would I handle it?

Lately many of us have had the chance to find out.

We are surrounded by danger. The Natural Hazards Center at the University of Colorado in Boulder catalogs two dozen separate hazards, from avalanches to sea fog. Much of the time

we appear to have them under control. We knock snow off slopes above highways with cannon; we see through the fog with radar. Like the levees along the Mississippi in 1993, these measures sometimes wrongly give us the impression of security.

But disasters are hitting us harder and harder. Last January's ice storm in Canada was reported as the costliest natural disaster in that nation's history and involved its largest peacetime mobilization of troops. In the United States the cost of all natural disasters has doubled in the past decade, from roughly 25 billion dollars a year to 50 billion dollars, according to government sources. This increase is part of the reason for a recent initiative by the U.S., Canada, and Mexico to catalog the Earth's dangers and find the patterns they draw across our lives. The effort has led to the map supplement in this issue.

There's debate about why hazard damage appears to be increasing.

"I can show you charts that indicate the costs of natural disasters are going up almost exponentially," says Chris Tucker, senior scientific adviser for Emergency Preparedness Canada. "But I can't prove that meteorological events have increased dramatically. A lot of us argue that increased urbanization and wealth in vulnerable areas are responsible." In other words, more people are spending more money on homes and businesses along hurricane-prone coastlines, in areas frequently hit by tornadoes, in earthquake-shaken valleys, or in fire-prone forests. The Canadian ice storm was devastating largely because of our dependence on fragile power lines; if it had happened a century ago, it would have been less disastrous.

I have recently been out wandering among catastrophes and visiting places where catastrophes are sure to come. There is a lot to learn from what has happened and what will happen again. Disaster kills, throws lives into disarray, ruins structure and order, turns safety to rubble, and changes lives for years—and it also shows us, without compromise, who we are.

C.M. GUERRERO, *EL NUEVO HERALD*

IN ACAPULCO *the water in Micaela's house is up to her chest. She feels herself shaking. She is shouting to her husband, Joaquin, for help. Can he hear? Rocks thunder against the walls. How long will the house hold?*

In the back of her house is a brick staircase to the roof. Joaquin and their oldest boy, Roberto,

lead the family one by one through the tearing water to the staircase. Soaked and scared, Micaela climbs to the roof. As they all get there, the roar of the water increases, the house shudders, and the stairway that saved them collapses and disappears into the flood.

Neighbors throw a ladder across a gap to the next house, which is intact. The family clambers across. The storm roars on. Out in the street that has become a river Micaela can hear the screams of people being washed away. She gathers her family and a crowd of frightened people into a circle in the neighbor's house, and they pray.

MICHAEL ADDARIO, CODE RED

TONGUES OF LETHAL FIRE, lightning takes at least 80 lives a year in the U.S. Less deadly but far more destructive, hurricanes rewrite lives and landscapes. After Hurricane Andrew hit Florida in 1992, Harold Keith (left) stood in awe and wondered: "My God, what happened?"

ON THE OUTSKIRTS *of Jarrell, Texas, while Paul and Joan Warhurst race toward the black cloud, many others try to protect their lives and families from the tornado.*

About a mile west of the Warhurst home, in a house built by her father-in-law, LaDonna Peterson huddles in a bathroom with her mother-in-law and sister-in-law, seven-year-old son, and six-year-old niece. Some people will later say that the tornado roars like a jet, but LaDonna will never remember any sound. What she remembers is singing for the children. "We sang 'Old MacDonald's Farm' and 'Jesus Loves Me.'"

IN THE SAN FERNANDO VALLEY *Sander Halet stands in the doorway to the bathroom, the world shaking around him. When will it end, and how will it end? The building groans and creaks, and there are sounds of things breaking. It goes on and on and on.*

Then it stops.

That is the most intense moment Sander will remember. Because when the noise of the earthquake stops, there is another sound.

"There is no more shaking," he tells me, "no more loud, trembling sounds. Just the screaming. It's something you should never experience: the echoing sound of people all over the place, men, women, and children, everyone crying out in unison."

ONE OF THE first things people in catastrophes ask is, Why? Science explains disasters simply: A strain in the Earth's crust that has built up over centuries releases its tension, the land slips three feet, and the ground shudders into an earthquake. An updraft of heat and moisture grows off a cornfield and starts to spin into a twister. Lightning strikes a tree and lights a fire. Rain falls into a layer of cold air and turns to ice. A warm sea pours energy into a swirl of storm clouds.

People in pain sometimes want to assign blame. In Grand Forks, North Dakota, which was drowned in April 1997 when the Red River of the North rose to 54 feet, people blamed forecasts that predicted lower levels: "49 feet my ass" read a sign sprayed on one ruined building. Some people believe that disasters are punishment from God.

But I've heard that mostly from those who observe catastrophe; I seldom hear about punishment from victims. They're bewildered and stunned, both by the power of the force they've seen unleashed and by the question of why they were chosen to suffer. It's an ancient question and has never been answered. After all, the voice from the whirlwind that talks to Job in one of the darker parts of the Old Testament does not tell him he is an evil man or a sinner. It shows him only that he will never understand. After Job was tested, God gave him back his fortune. But for most people who feel the impact of a disaster, the test has just begun.

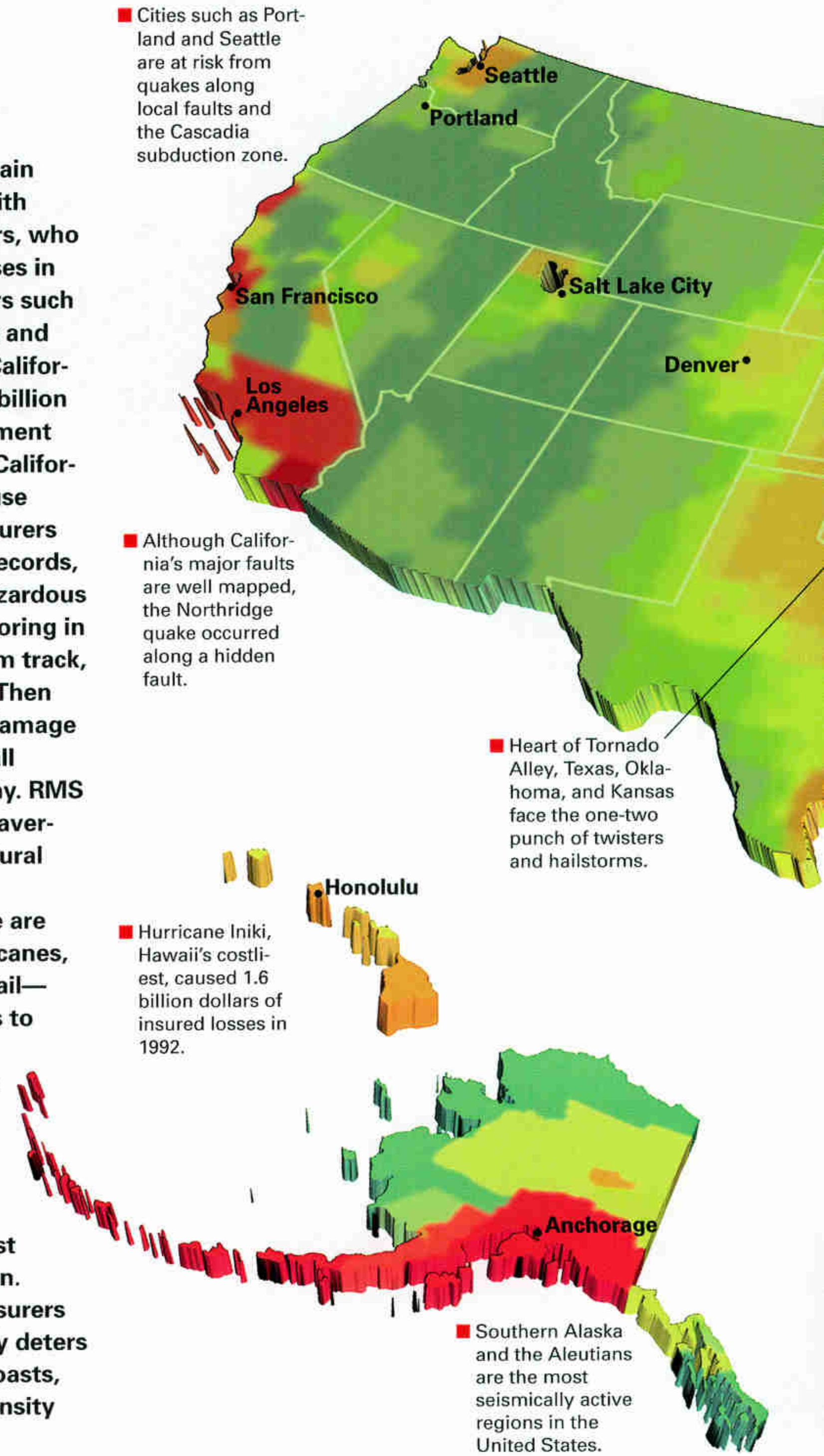
IN THE FORESTS *of eastern Ontario there is a sound like gunfire. A gentle rain has been falling*

WHERE HAZARDS LOOM LARGE IN THE U.S.

Living in the shadow of risk

PROJECTING RISK is an uncertain science. Yet it's one pursued with increasing vigor by U.S. insurers, who have taken unprecedented losses in the 1990s from natural disasters such as Hurricane Andrew in Florida and the Northridge earthquake in California, which together totaled 28 billion dollars in claims. Risk Management Solutions, Inc., of Menlo Park, California, is one of many firms that use computer modeling to help insurers assess risk. Based on historic records, RMS first simulates a set of hazardous events such as hurricanes, factoring in variables like wind speed, storm track, and probability of occurrence. Then it assesses the percentage of damage a given event would cause to all types of buildings in harm's way. RMS can then estimate an insurer's average annual loss from these natural calamities.

Shown here for the first time are RMS's combined data for hurricanes, earthquakes, tornadoes, and hail—four of the most costly hazards to insurers. (Flooding, largely covered by the federal government, is not included.) Losses in the most hazardous areas, shown as dark red patches, would be at least 45 times greater than those in the lowest risk zones, shown as dark green. Such knowledge may move insurers to alter their rates, but it hardly deters people from moving to risky coasts, as the adjoining population-density map shows.



■ Cities such as Portland and Seattle are at risk from quakes along local faults and the Cascadia subduction zone.

■ Although California's major faults are well mapped, the Northridge quake occurred along a hidden fault.

■ Heart of Tornado Alley, Texas, Oklahoma, and Kansas face the one-two punch of twisters and hailstorms.

■ Hurricane Iniki, Hawaii's costliest, caused 1.6 billion dollars of insured losses in 1992.

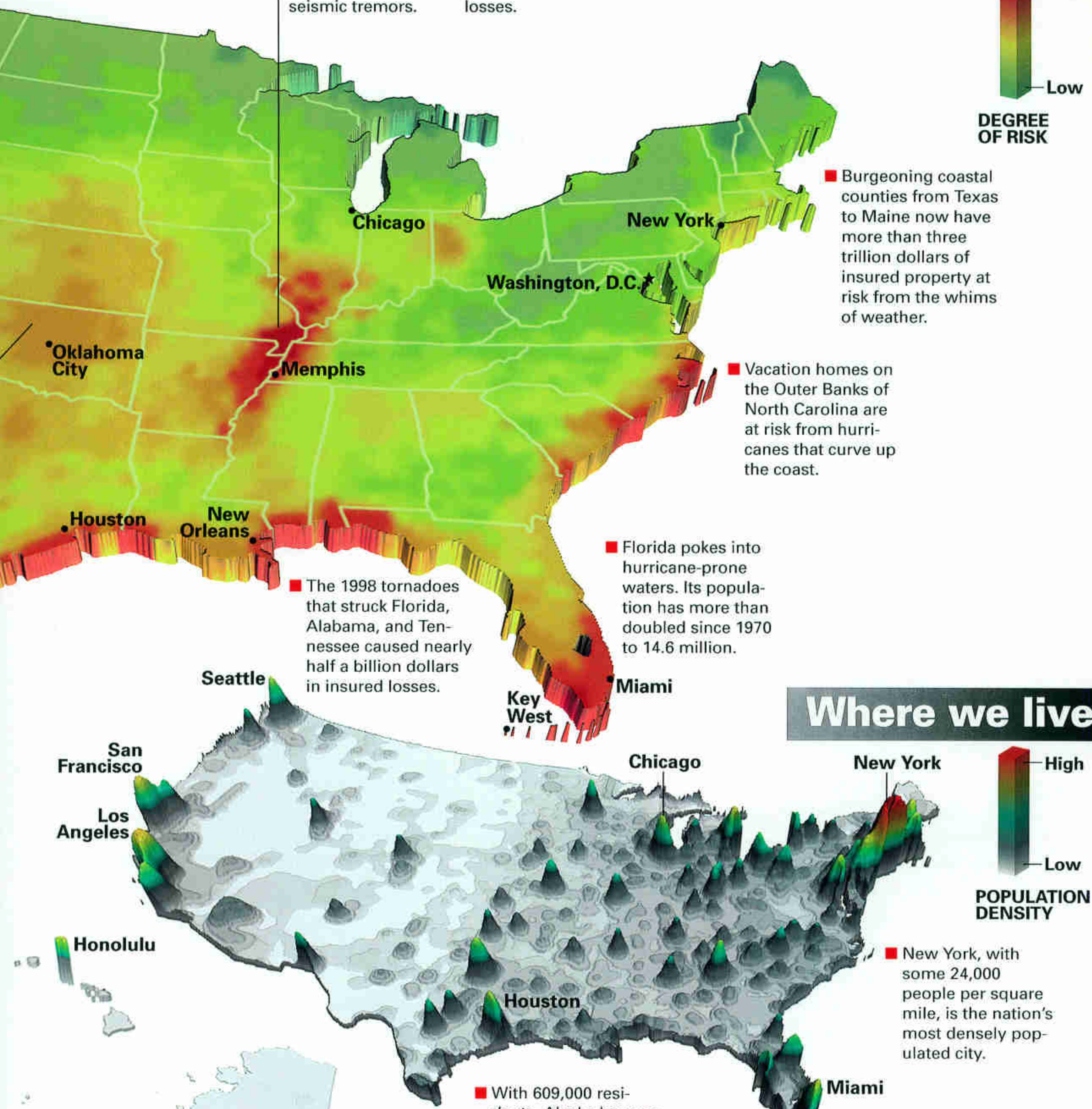
■ Southern Alaska and the Aleutians are the most seismically active regions in the United States.

SCALES VARY IN THESE PERSPECTIVES.
3-D RENDERINGS BY BRIAN STRAUSS, NGS

RISK IS RELATIVE. But fear of calamities such as volcanic eruptions, earthquakes, hurricanes, and twisters haunts the imagination. Here are some U.S. statistics about hazards—wrought by nature and humans—to help put risk in perspective.

- **2.3 million Americans die each year of all causes.**
- **On average, fewer than 350 people each year die from floods, lightning, tornadoes, hurricanes, earthquakes, volcanic eruptions, and hail.**
- **According to the National Weather Service, from 1967 through 1996 flooding caused an average of 138 deaths a year, followed by lightning at 83, tornadoes at 70, and hurricanes at 24. Though**

Places at risk



■ The New Madrid Fault threatens the central U.S., where structures are not built to withstand seismic tremors. RMS estimates that a magnitude 8 quake here could cause more than 70 billion dollars in insured losses.

■ Burgeoning coastal counties from Texas to Maine now have more than three trillion dollars of insured property at risk from the whims of weather.

■ Vacation homes on the Outer Banks of North Carolina are at risk from hurricanes that curve up the coast.

■ Florida pokes into hurricane-prone waters. Its population has more than doubled since 1970 to 14.6 million.

■ The 1998 tornadoes that struck Florida, Alabama, and Tennessee caused nearly half a billion dollars in insured losses.

Where we live

■ New York, with some 24,000 people per square mile, is the nation's most densely populated city.

■ With 609,000 residents, Alaska has one person per square mile, the nation's least densely populated state.

economically destructive, hail is seldom lethal; it has caused eight deaths in the 1990s. In the past ten years quakes have killed 130 and totaled more than 25 billion dollars in damages. The 1980 eruption of Mount St. Helens killed 57 people.

■ Analysts estimate that the drought and heat wave of 1988 caused 5,000 to 10,000 deaths and losses of nearly 40 billion dollars, which would make it the deadliest and costliest U.S. weather disaster ever.

■ Homicide and police actions take roughly 22,000 lives a year.

■ Motor-vehicle accidents cause some 42,000 deaths each year.

■ AIDS killed 39,200 in 1996, down from a peak of 50,700 in 1995.

■ Deadliest of all, heart disease killed an average of 743,000 Americans each year from 1975 through 1995.

for days from warm air into cold; it freezes to everything it touches. First it makes the landscape as pretty as Christmas. The air sparkles, the trees glitter, the power lines shine. But the soft rain falls and falls, and soon the power lines break, and villages, towns, and cities go dark. Now, long after the pretty rain has turned to disaster, Gail McAllister stands outside the front door of her house near a small town called Vankleek Hill and listens to the shattering of the forest: cracks, shots, thumps, crashes, splintering explosions. It is the sound of trees falling, breaking off, or losing branches. It is eerie and frightening. "Thump, thump, thump," she says later. "The ground would almost shake."

This changes Gail's world. The power will be back on in a month, but the forest won't be back for a generation.

"THE DARK TIME HAS SET IN" *in Jarrell, Texas, as LaDonna Peterson will say later. It is pouring with rain, and in heavy twilight all you can see in the place that was the Double Creek Estates subdivision is debris and slabs of concrete where there were homes. The roaring noise has gone, but it has taken 27 lives.*

LaDonna Peterson has survived. She and her family struggle out of the bathroom, which is about all that's left of the house. She sends the kids to take shelter at a neighbor's and goes to the other ruins to see if she can help. The first thing she finds is a young girl lying in a field, badly injured. She sits with her until the ambulance comes.

"I'm glad the first people I came on were living," LaDonna says. "I'm glad I didn't see what I didn't want to see."

Paul and Joan Warhurst arrive at what is left of their house. Covered with smashed glass and a froth of pink insulation, some of it still stands. Joan leaps from the van before it stops and runs toward the ruins. She hears a wonderful sound she will never forget:

"Mom! Mom!"

It's her kids. They're safe.

ON TELEVISION NEWS a disaster is like a meteor. It burns brightly then is gone. Another drama quickly eclipses it. After the tragedy of destruction is announced, the disaster is over.

This is not the case for the people who are there. Now they need help, and for a long time.

The response to disaster reveals something important about human beings. It is simple, though it sounds sentimental: For some reason humans have a huge capacity for empathy, for giving, for helping those who are hurt.

This need to help seems as instinctive as the Warhursts' desire to find their kids in the tornado. For some it is an instant generosity. Almost immediately after the Red River flood in April 1997, checks and cash piled up in the office of the Red Cross in Winnipeg, Manitoba; those donations reached a total of 22 million Canadian dollars (15.3 million dollars U.S.). Others spontaneously give time or energy, like the people who just showed up at the Jarrell school, ready to fold clothes, wash dishes, cook food, clean up debris, do anything to fill a need.

Response comes quickly, because it must. People have to be saved from the ruins, brought to hospitals, protected from looting and other lawlessness, sheltered if they're homeless, and, because disaster can strip you bare, they must be given water, food, and clothing. Depending on the size of the disaster, response can last from a day to many weeks.

IN ST. JUDE CATHOLIC SCHOOL *near Vankleek Hill, Ontario, the halls thump with military boots. Sixty-five members of the Cameron Highlanders of Ottawa, a reserve unit called up for the ice storm, are bivouacked in the classrooms. Down the long halls, now dimly lit by emergency light, there's a murmur from the crowd in the gym. It is day eight of the ice storm disaster in Ontario and Quebec. More than three million people are without power, and 11,000 troops have moved into the countryside and cities, trying to help.*

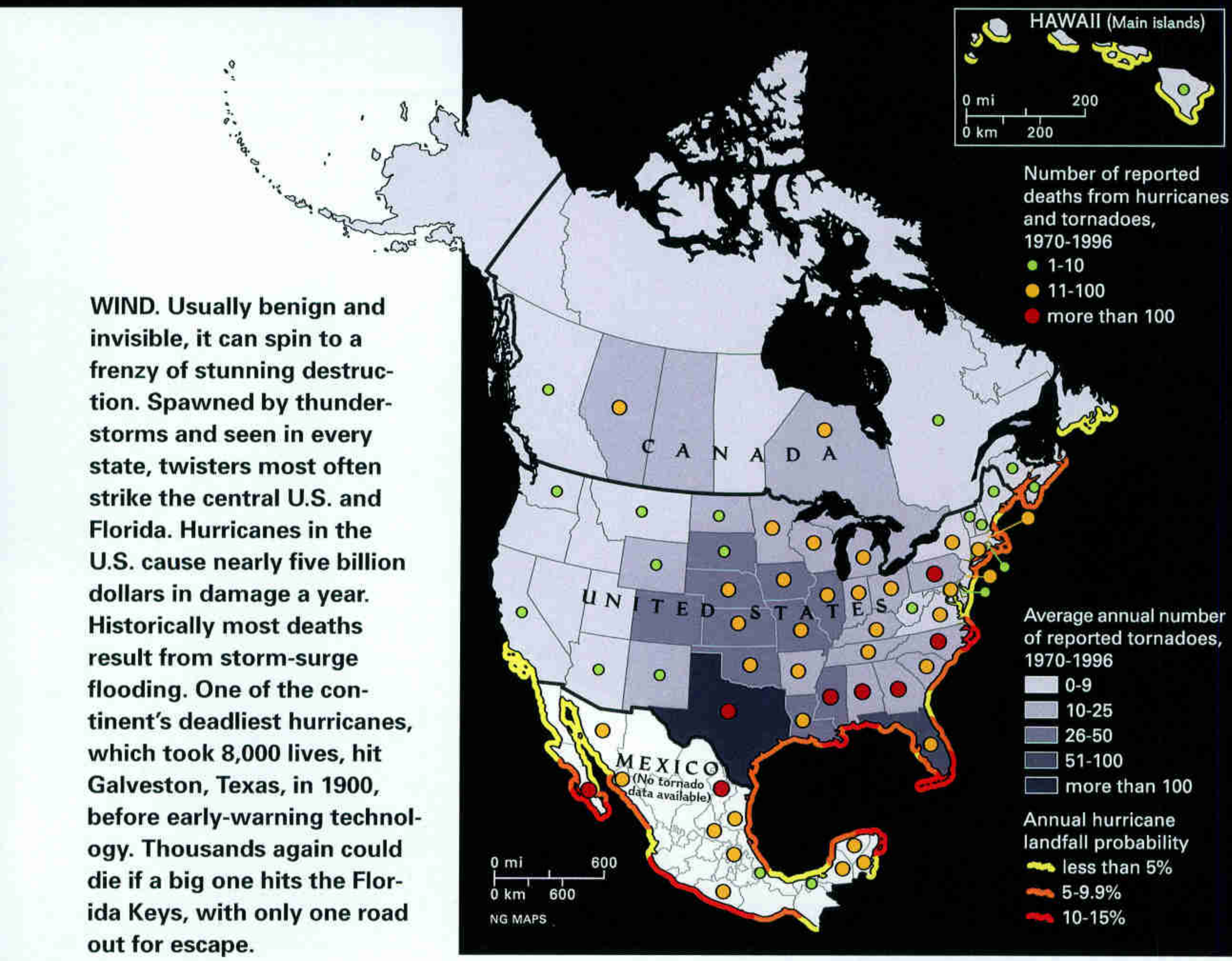
In the gym Scott and Gail McAllister have come in with their eight-month-old, Haley, for a hot meal paid for by the provincial government. They eat chicken and beans and chat with their neighbors.

The mood is cheerful but wary. "They're looking more tired and more discouraged now," says a volunteer. It's easy to see why. The party is over.

"They told me five days until the power came on," Scott says, "but I just heard a month."

A band starts setting up under one of the basketball backboards. I ask the drummer what the

HURRICANES AND TORNADOES A wide path



WIND. Usually benign and invisible, it can spin to a frenzy of stunning destruction. Spawned by thunderstorms and seen in every state, twisters most often strike the central U.S. and Florida. Hurricanes in the U.S. cause nearly five billion dollars in damage a year. Historically most deaths result from storm-surge flooding. One of the continent's deadliest hurricanes, which took 8,000 lives, hit Galveston, Texas, in 1900, before early-warning technology. Thousands again could die if a big one hits the Florida Keys, with only one road out for escape.

band's name is. He looks at me as if I'm crazy. Then, making do like everyone else, he comes up with a name on the spot: "Let's call it the Vankleek Hill Disaster Band."

It looks as if the band will have a lot of gigs before it can change its name again. "This power grid was not built in a day," a government spokesperson said earlier today.

IN THE FACE OF BIG DISASTERS there is a big, institutionalized response. In Mexico the military and the Red Cross respond first; in Canada the responsibility for initial help lies with the individual municipalities, then with the provinces. The largest disasters in the U.S. are handled by FEMA, the Federal Emergency Management Agency. Established in 1979, FEMA responds when the President declares a region a federal disaster area. FEMA has a full-time staff of about 2,600 but maintains some 4,500 trained standby workers who drop everything to help when a disaster is declared. In Grand Forks FEMA appeared even before the water crested, eventually renting 17,500 square feet of office space and putting almost 300 people to work on the flood.

This part of disaster response tells us good things about ourselves. But there's an ugly side too. Marriages suffer, depression and substance abuse increase, and, according to one study, the rate of suicide goes up as well. Some people contribute to the anarchy that can immediately follow a disaster by looting damaged or evacuated homes and businesses.

After Hurricane Andrew hit Homestead, Florida, in 1992, hundreds of looters ransacked parts of town. "The really bad side of some people came out," said Tad DeMilly, who was mayor at the time. "Those were mostly people who came in to loot. But we had moms who had no food for their babies also in there looting for survival. We couldn't arrest looters because we had nowhere to put them. It was verging on anarchy." *(Continued on page 23)*

TORNADO Scourge of angry wind

ALL BY SCOTT BECKWITH

THE NIGHTMARE FOR JARRELL, TEXAS, began on May 27, 1997, as a sinuous rope in the sky. A maverick, the tornado moved remarkably slowly, split into multiple vortices, then merged into a ravenous funnel with winds estimated at more than 200 miles an hour. Little in its path survived.

TORNADO Random touch of tragedy

THIRTEEN MINUTES. It seemed an eternity for the Jarrell tornado to cover five miles and blow the Double Creek neighborhood into barren oblivion (right). Home that day and later mourned (above), the Igo family accounted for five of the storm's 27 victims. María Isabel Hernández and her three children survived in a 7-by-9-foot cellar (below) that she and husband Gabriel had dug beneath their home, by the U-shaped drive. Says Gabriel, who lived through a 1989 tornado, "If I didn't have that cellar, I wouldn't have a family."

KEVIN VIROBIK-ADAMS FOR THE *AUSTIN AMERICAN-STATESMAN* (RIGHT); RON T. ENNIS, *FORT WORTH STAR-TELEGRAM* (TOP)

TORNADO The grip of grief, the hand of hope

"KYLE SUFFERS from the loss of all the little kids that died around him," says Vicki Woodward, whose son, Kyle Williams, plays on a neighbor's ruined homesite. Yet healing has begun. Beads, baseball cards, and scattered treasures found in Jarrell's fields adorn a makeshift memorial to three boys who died (below). Hundreds of volunteers donated time and money to help residents rebuild. "I am eternally grateful," says James Taylor, whose family was loaned a trailer home. "We realize how much we did *not* lose."

(Continued from page 17) For a while Homestead was like the Wild West, with homeowners roaming the streets carrying sidearms and rifles. "I was packin' a gun," said one restaurant owner. "All my friends were packin'." Then the troops came in, and things settled down.

The first part of the human recovery from a disaster ends when disorder gives way to a surface routine built on the raw new landscape. It is then replaced by a phase that calls for altogether different qualities.

"YOU GET TO A POINT," *says Sander Halet, "where you're OK and your family's OK and you're not injured or going to die of starvation or anything, but—hey, you've got to rebuild your life. You get to that realization, and it's very humbling."*

During the response to the quake Sander worked hard cleaning up debris and hauling batteries and jugs of water to his father's neighborhood. But now the drama has ebbed from his life, and he can't figure out what to do next. He hears that FEMA and the Red Cross can help, so he shrugs his shoulders and checks it out.

"I go and stand there, and there's lines, like, whoa! I don't even know what I'm standing in line for. Then it's: 'What's your situation? Where do you work? How much were you making?'"

Sander is amazed at how well the Red Cross knows what survivors need; the concern from others wakes him up and gets him thinking ahead. College, a better job, cooking for himself. "What helps is they have it planned out," he says. "'Here's vouchers for what you're going to need.' I get vouchers for pots and pans! I never think about pots and pans."

IT IS A ROUGH WEEK *in Homestead since Andrew ruined town. There are 16,000 troops in southern Florida now, keeping order, helping clean up. The Red Cross, Salvation Army, and a score of other aid groups are providing food and clothing. FEMA is planning temporary cities of trailers and preparing to give out checks. The first response is under way, and it's time to think of long-term recovery.*

A delegation has come from Charleston, South Carolina, which was devastated by Hurricane Hugo in 1989. They're here to offer advice based on what they learned from their own catastrophe. They meet with Eliza Perry, Tad DeMilly, and other members of the city council.

"Recovery will take you five years," say the people from Charleston.

"We told them thank you," Eliza says later. "We told ourselves: three years."

They were wrong.

RECOVERY. A SIMPLE IDEA. "A dynamic and complex issue," says Eliza Perry, looking back over five and a half years, after which Homestead is still not back to the way it was. After a disaster the whole geography of life has changed. How do you put everything back together? You don't. You build something different.

The systems that support rebuilding vary significantly. In Mexico there is less federal assistance than in the U.S. or Canada. ("In Mexico they say, 'God helps those who help themselves,'" an observer told me.) So María Micaela Alcaraz de Castillo did not expect the government to help her family; it would only tell them whether they would be allowed to rebuild on the same site. If not, she said, they would be forced to buy land elsewhere. This could push them down from their hard-earned lower-middle-class status to rock-bottom poverty. In Mexico, however, disaster victims often find aid from extended families, which are often more extensive and helpful than elsewhere in North America.

The U.S. and Canada are more bureaucratic about their giving. In Canada the municipalities and provinces offer immediate disaster assistance and rebuilding funds, backed up by the federal government. In the U.S. people turn to the feds more quickly. When a federal disaster is declared, FEMA can speed money to people directly, and loans are available from the Small Business Administration for rebuilding. If damage is widespread, like that caused by the 1993 Mississippi and the 1997 Red River floods, FEMA sets up entire parks of trailer homes, which people call FEMAvilles. In some cases FEMA also helps subsidize victims' rent.

But whatever its level of financial help, the government cannot repair your spirit. That's a part of dealing with disaster that you have to do on your own.

IT IS A BRIGHT NOVEMBER DAY *in Jarrell six months after the tornado. The sky is almost clear, and the air is calm. As I drive through*

VOLCANO Menace within the mountain

FEARSOME NEIGHBOR, Mexico's Colima volcano steams above San Marcos, one of seven villages within the nine-mile reach of the deadly pyroclastic flows from the last big blow, in 1913. "We expect the next large eruption within my lifetime," says Juan Carlos Gavilanes, whose team monitors changes in magma gases.

the Double Creek Estates subdivision, it is impossible to imagine how this small patch of ground on a broad, rolling plain could have been singled out for such destruction.

At the end of one street someone has stacked concrete blocks near an empty slab, and kids and neighbors have made an impromptu shrine adorned with plastic flowers, a wooden cross, and a few poignant bits of debris—a knife, a pop bottle, a nozzle to a fire hose, a necklace of beads, and a tiny blue cloth heart. On the shrine is a handwritten sign to three teenagers who died here: "In memory of Erik Allen Moehring and John & Michael Ruiz. We'll miss y'all."

Dozens of tidy new homes stand in the wintry brown grass. LaDonna Peterson has a new double-wide trailer bought with savings and a federal grant. It's strapped down to a concrete foundation. Paul and Joan Warhurst had to tear their old home down; in its place rises the frame of a two-story house with a concrete storm cellar so heavily reinforced it would probably survive World War III.

"We've made remarkable progress in six months," says Dianne Johns, the head of the Jarrell Recovery Board. "But that's only the material recovery. The victims have got their shelter back, but they have other issues to deal with."

A few hundred yards from Double Creek Estates is Esther Tschoerner's place. She and her husband survived the storm, but their home was wrecked. Now they live in one of four new concrete houses provided to Jarrell by a construction firm. She feels like a stranger in her new home, and she has not yet become used to the knowledge that some of her neighbors will never return.

"I still look for some of them going down the road," Esther says. "As long as I stay busy, I'm fine. It's at night or when there's nobody around. I start thinking, and that's when it gets hard."

Down the Tschoerners' long driveway are several trees that survived the storm. High in the branches of one is a piece of bent-up corrugated roof. As if to challenge fear, she has decided not to take it down.

"I keep it there as a souvenir," she says, working on her recovery with a smile. "You have to be able to laugh."

YOU ALSO HAVE TO HOPE. That, too, is part of the human need after a disaster. And one of the great hopes victims nurture is that they can do something with what they've learned so that disaster won't hit so hard next time. Disaster professionals call this mitigation. Mitigation is the practical side of hope; it includes such tactics as bolting

AN EIGHT-INCH SHIFT beneath Los Angeles in 1994 toppled highways and bridges and sent Officer Clarence Dean hurtling to his death as he rode to work on a motorcycle. A colleague grieves at the scene for Dean (below), one of 61 people to die in the 6.7 magnitude quake.

Because many concrete bridge supports crumbled during the quake, the state is shoring up hundreds of bridges by fitting columns with steel jackets (right). "This will help prevent catastrophic failure when the next one hits," says engineer Gary Plunkett.

DAVE YODER, *ORANGE COUNTY REGISTER* (ABOVE)

down buildings and heavy appliances in earthquake country; improving the structural integrity of roads, bridges, power distribution, and other public works; using new building techniques to make sounder homes; and developing zoning regulations to reflect new knowledge of hazards—keeping new houses out of a floodplain, for instance.

Doing all these things seems logical, but the need to hope for less damage next time gets offset by another human factor: politics.

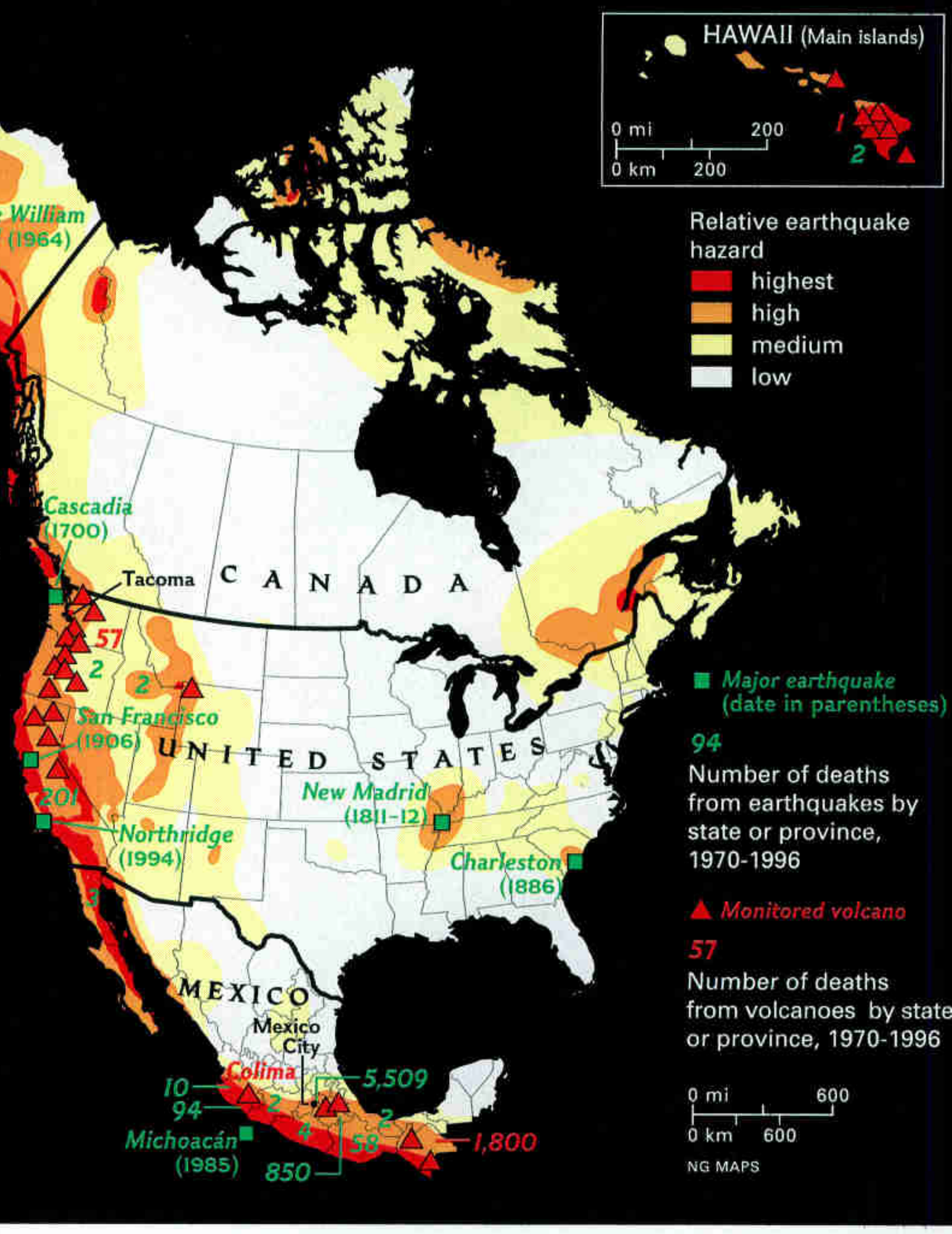
"There are significant political and social issues associated with most mitigation efforts," said Fred Samuel, director of disaster services for the Red Cross in Santa Barbara, California. In that city an obvious bit of mitigation against the wildfires that regularly wipe out hundreds of homes is to outlaw wood shingles, but powerful lobbies stand against it. After dozens of major fires a regulation prohibiting the installation of new wood roofs was passed in 1990.

This hope to be wiser the next time can also complicate recovery. Though you want to get new structures up for homeless residents as soon as possible after a hurricane, you also want to make sure the builders use the most recent innovations in storm protection. But in the building boom that follows a disaster, there often aren't enough inspectors to make sure the new codes are followed.

A BURST OF COMPRESSED AIR *blasts out of a 20-foot PVC pipe, shooting a two-by-four 14 feet long at 100 miles an hour. That's about the speed it would fly in a 250-mile-an-hour wind—faster than Hurricane Andrew but less than the highest estimated speeds in the Jarrell tornado. The board slams into a concrete wall and shatters like glass. Splinters fly.*

This is more violent than I had expected. No wonder wind kills people.

I'm in the huge basement lab of the Wind Engineering Research Center at Texas Tech University in Lubbock. Stacked near the gun are



NORTH AMERICA'S western edge seethes beneath the surface. Oceanic plates that grind past or dive under the continent cause a hundred damage-producing quakes a year and can lead to volcanic eruptions. Dozens of active volcanoes run from Mexico to the Aleutians, putting Mexico City, Tacoma, Anchorage, and other cities at risk.

various chunks of brick, wood, and aluminum-sided walls—the crash-test dummies of the building trade. Many of them have been shot through by two-by-fours. These walls will not protect you much in tornado country.

Russell Carter, a member of a Texas Tech disaster survey team, shows me around. In the past 28 years Texas Tech has studied wind damage at 95 disasters from coast to coast to figure out what kind of mitigation works.

With a deliberate intensity Russell, who visited Jarrell the day after the tornado, shows me photographs of the damage. He points out how the bases of some walls were nailed to concrete slabs rather than bolted down; the wind yanked those walls out. In some houses the bases of the walls were cut through for plumbing; in the pictures those walls are broken, and the house is gone.

"First the garage door blows in," Russell says, "then the roof lifts off, and, with little anchoring, things start coming apart. With the wind incessant for possibly minutes you wouldn't expect those houses to hold together."

Several of his photographs are of the house LaDonna Peterson took shelter in. Some walls still stand. Russell says that may be because her father-in-law, a creative builder, put it together using old steel doors for walls.

At Texas Tech, near the big gun, the test walls are held together by metal straps, anchor bolts, or ties. "In a $50,000 or $60,000 home," Russell says, "it only costs a few hundred more to buy ties and strap." Would that have saved lives in Jarrell, where the tornado moved across the ground at five or ten miles an hour instead of a more normal forty?

"I don't know," he says. "The tornado moved so slowly. It just sat there and churned and churned. I can't imagine what it would be like to be in a tornado as long as those people were."

THE COMBINED CHOIRS *of the high school and middle school in a town near the Mississippi*

WILDFIRE Feeling the heat

AN ARSONIST'S blaze in the parched canyon above Laguna Beach, California, triggered the worst urban wildfire of 1993. Flames raced down the hills, devouring scrub and million-dollar ocean-view homes with equal appetite. The inferno torched some 14,000 acres and 441 houses.

Greg Kearns's home was not one of them. The Emerald Bay resident kept vigil atop his shake-roof house with a garden hose (right). Though the hose only dribbled due to lack of water pressure, Kearns saved his home and two of his neighbors' from flying embers that ignited other structures like tinder. "This intense roaring fire was amazing," says Kearns. "It looked like a war zone."

The Mystic Hills neighborhood took the worst hit, with 286 homes turned to ash. One that survived (right) had a fireproof tile roof, stucco walls, extra insulation, and fire-resistant landscaping that kept it safe until firefighters came. "I cried, then I laughed," says relieved owner Doris Bui-Bender. New houses here (far right) are required to use fireproof roofing. But they'll need luck too. California had 8,989 wildfires in 1993 alone. And fire's tricky. "It jumps," says ecologist Mike Harding.

CHAS METIVIER, *ORANGE COUNTY REGISTER*

BRUCE STRONG, *ORANGE COUNTY REGISTER*

River called Valmeyer are singing the "Hallelujah Chorus." As has happened for years, graduates come down from the stands to sing with the gowned kids, and the resounding celebration fills the bright new rafters of the new gym, renewing tradition in a place where nothing physical is familiar.

Valmeyer, a town of 900 that was inundated repeatedly in 1993, has done the ultimate mitigation. With help from FEMA the whole town moved to higher ground.

Floods are both expensive and repetitive, FEMA economists reason, so moving potential victims away from floodplains may cost less than bailing them out again and again. A program that includes doing just that has been going since 1988, but this is the first time FEMA has moved an entire town.

It took a determined community led by a self-proclaimed "pain in the ass" to do it. The pain was Dennis Knobloch, mayor when Valmeyer went under. He became city administrator and badgered politicians and bureaucrats until a new Valmeyer was born.

It was not simple. The city had to buy the mineral rights to a quarry under the new town and search for endangered bats. But it worked.

"The key thing that made this successful," Knobloch says, "is that the people were involved from the beginning. They created the community themselves."

The morning after the concert I drive through the new town—a collection of homes built on rolling hills several hundred feet above the floodplain. It is very pleasant, but some people here used to call themselves river rats, and I wonder how this basic shift in geography has affected them.

"I'm homesick," says Charlotte Gartzke, secretary to the school superintendent. "It was like a death." Charlotte and her husband now live in the new town. "The town did die. You had denial, guilt, all those steps." She smiles, a little wistfully. "Now you might be in a new location, but it's Valmeyer. I still have the same zip code."

ONCE YOU'VE BEEN through a disaster, it seems that nothing is more important than this desperate brush with the Earth's power. But as disasters recede into memory, we get less concerned about preparing for them.

IN THE SHADOW *of an active volcano called Colima, south of Guadalajara, Mexico, the town of San Marcos lazes through a pleasant afternoon. A huge Mercedes bus rumbles through town, followed by a man leading a burro with a bundle of sugarcane on its back. Kids kick a soccer ball. From behind doors there is the sound of women singing about the favorite Mexican saint, the Virgin of Guadalupe.*

"Desde el cielo una hermosa mañana, La Guadalupana bajo . . . ," *they sing. "From the sky one beautiful morning, the Virgin of Guadalupe came down. . . ."*

No one ever seems to glance at the sign above the street, which warns, with green, red, and yellow lights, of different levels of activity on the mountain. Today the green light is on.

I ask Francisco Arenas if he'll leave when the light turns red.

"I will leave when the priest leaves," he says. Francisco has one brown eye and one blue eye; the blue one is glass. He sits by an open door on Avenida Independencia. A friend sits next to him, holding a baby in a blue dress on his lap.

"I don't need to run," Francisco goes on, "because when it is time, that is when you die."

Eight miles northwest of San Marcos, Colima steams quietly, a postcard peak. But it is deadly. Colima is one of the most active volcanoes in Mexico; it blows up about every 80 years, the last time in 1913. Small eruptions have come as recently as 1994. It is due to blow again.

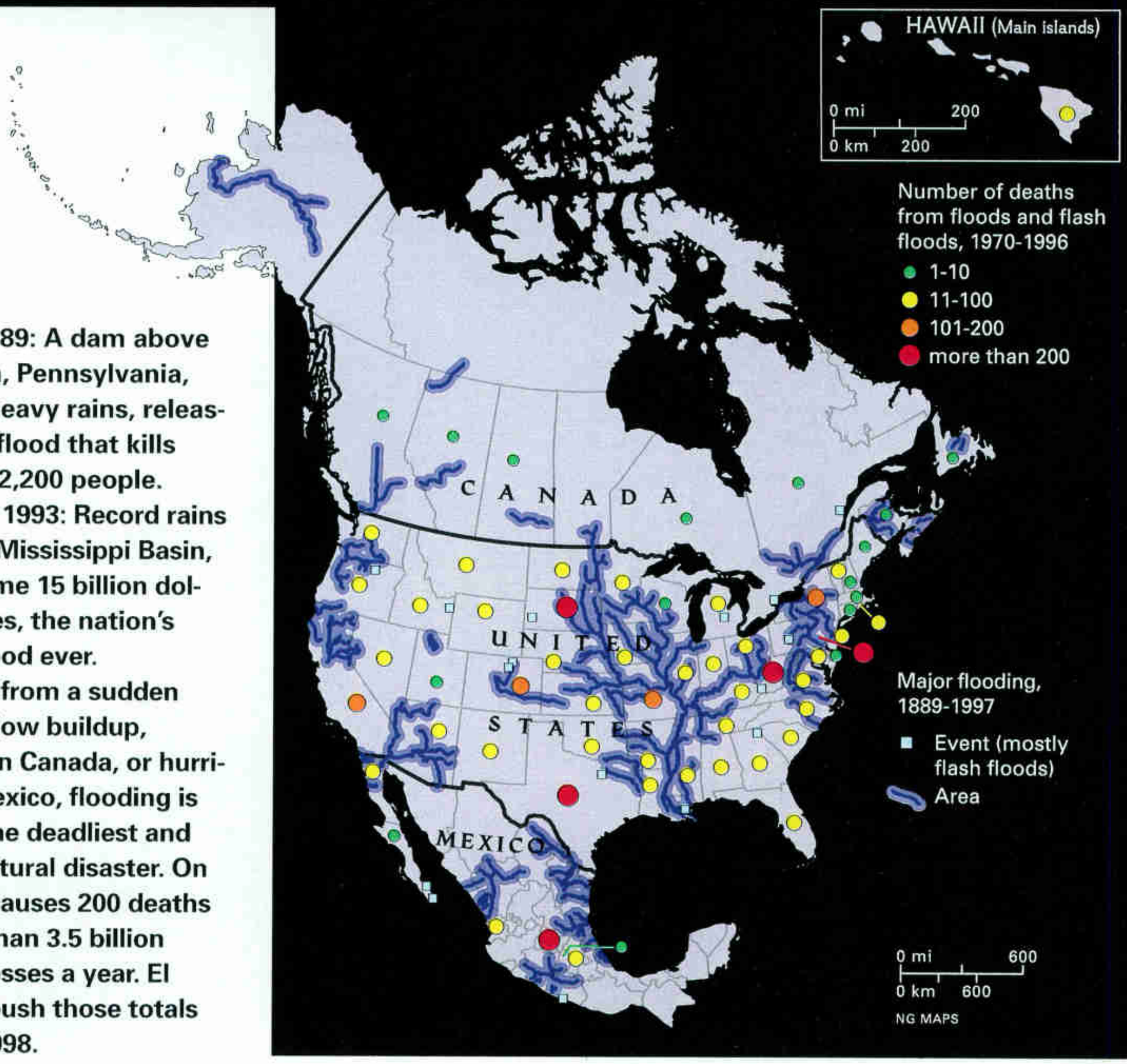
Juan Carlos Gavilanes, a volcanologist at the University of Colima, shows me how most of the nearby towns and cities—home to 300,000 people—are built on the volcano's debris. Yet in some there's a placid acceptance that comes close to denial.

"People told us they know there's going to be an eruption," he says. "But a dangerous one? They don't think so."

As I drive from village to village around the base of the mountain, through towns that may soon be smothered by ash, swept away by racing flows of hot gas and debris, or ruined by volcanic mudflows called lahars, the familiar response is a shrug. That gully will stop the lava. The mountain looks close but is really far away. If God wants you to die, you will.

With Juan Carlos and several of his colleagues I climb the dark flanks of the volcano. At the summit, steam emerges from between

FLOODS When water goes wild



MAY 31, 1889: A dam above Johnstown, Pennsylvania, fails after heavy rains, releasing a flash flood that kills more than 2,200 people.

Summer 1993: Record rains drown the Mississippi Basin, causing some 15 billion dollars in losses, the nation's costliest flood ever.

Whether from a sudden torrent, a slow buildup, snowmelt in Canada, or hurricanes in Mexico, flooding is generally the deadliest and costliest natural disaster. On average it causes 200 deaths and more than 3.5 billion dollars in losses a year. El Niño may push those totals higher in 1998.

broken stones. It is so laden with sulfur and chlorine that we have to wear gas masks or cough helplessly. Breathless at 12,700 feet, I watch the team sample the gases to learn what chemical changes may signal activity. Recently they discovered two incandescent fumaroles, where you can look down into a crack in the rock and see a glow. It looks like the volcano's red eye, the implacable glare of its awakening.

The fumarole murmurs, the red eye never blinks, and I think of those in the villages, singing: "From the sky one beautiful morning. . . ."

ON THE ROAD *from Homestead, Florida, to Key West, Billy Wagner preaches to anyone who will listen: It's coming! It's coming!*

Billy is not a wacko doomsayer. He's the emergency management chief for Monroe County, which includes the keys. He has science on his side: Sooner or later, meteorologists predict, a major hurricane will strike the heavily populated islands that make up the keys and will rip the human structures there to shreds.

"Jeez-em crickets!" he says. "They gone be annihilated!"

Billy talks like the good old Louisiana bayou boy he claims to be, but he's been a respected emergency planner for more than 20 years. His plans would allow most of the keys' 77,000 residents and as many as 50,000 visitors to evacuate under a dire forecast, but too many people say they're going to stay home and ride it out.

He thinks they're foolish. In his office in Marathon he draws high-water lines across my map of Key West. The lines show where a storm surge will reach. They don't leave much dry land.

"Man, I'm gone tell you," he says. "If Andrew'd 'a' struck here, we'd 'a' lost thousands."

Back in 1935 a bad hurricane hit the islands well north of Key West and killed hundreds of men living in veterans camps. Ernest Hemingway went up from his house in Key West and saw dead vets stuck in mangrove trees. "It doesn't take a bird dog to locate them," he wrote.

At Hemingway's house in Key West, now a tourist site, no one seems worried.

"Didn't you know," says one supercilious expert, "that there's a sign on the beach? It's written in English, Spanish, and Creole, depending on where the storm's coming from. It says Turn Right. So the storms go up and smash the Carolinas."

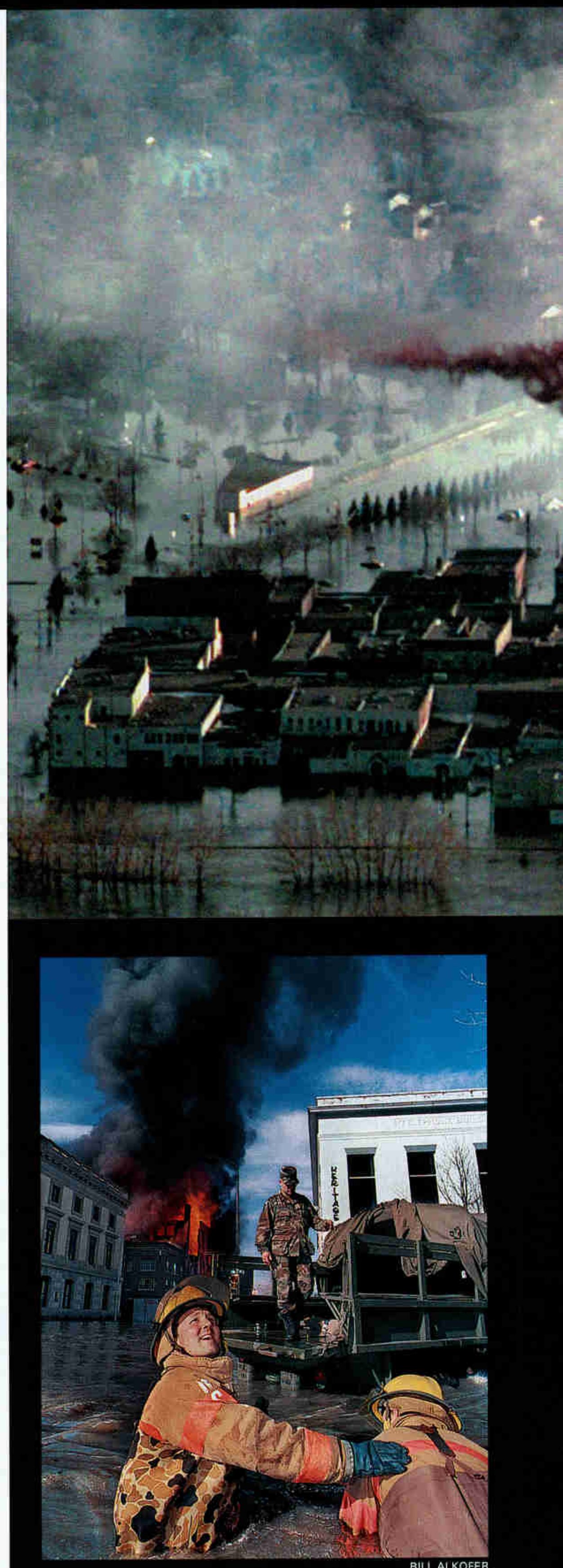
A guide repeats the hurricane theories I hear all over town—theories not supported by meteorology: Hurricanes don't come here because they hit the mountains of Cuba and disintegrate. Hurricanes don't come here because they tend to go north. Hurricanes don't come here because in 1922 a devoted nun dedicated a grotto shrine to protect the town.

"That's really why we're protected," the guide says. "If there are hurricane warnings, I'll buy candles. I'll probably end up in one of the churches. I'd pray my way through it."

All this reminds me of one of Billy Wagner's favorite sayings: "I work with two of the most unpredictable things in the world: Mother Nature and human nature." So I stop to see him on the way back up the road that will someday be an escape lifeline—I hope. Billy thinks that prayer and devotion are good for the soul, but he would like to see Key West residents add more planning to the mix.

"I'm very religious," Billy says. "I need all the help I can get. And that's a great grotto down there. But you got to be sure you're ready. If they get the brunt of it, they gone be devastated."

WILL PREPARATION ever win our hearts? Will Billy Wagner or Juan Carlos Gavilanes ever get our attention? Perhaps. It might help if predictions become more accurate, and on many fronts they are improving. Meteorologists at the National Hurricane Center in Miami, armed with aircraft, satellites, and ever more sophisticated computers, claim an annual increase in forecast accuracy of one percent. Researchers in California and Mexico are not only developing more advanced tools to monitor quake-prone areas but also refining electronic warning systems that could, at the first thump of a big quake, race ahead of the shock to give nearby communities as much as a minute to get ready—at least enough *(Continued on page 38)*



BILL ALKOFER

CHUCK KIMMERLE, *GRAND FORKS HERALD*

JOE BRYKSA, *WINNIPEG FREE PRESS*

THE HUMAN INSTINCT to survive "come hell or high water" was mightily tested in spring 1997 as the Red River of the North brought record flooding to the upper Midwest and Manitoba.

Snowmelt from eight blizzards that dumped nearly 100 inches of snow around Grand Forks, North Dakota, pushed the river to 26 feet above flood stage there, inundating 75 percent of the town. Fires from electrical shorts destroyed 11 buildings despite aerial chemical drops (above) and firefighters' efforts to find hydrants hidden under freezing water (left). "It was surreal," says deputy fire chief Peter O'Neill.

Moving north across glass-flat prairie, the Red became a 25-mile-wide lake, swamping some towns, surrounding others. Canadian troops—many of them veterans of foreign peacekeeping missions—sandbagged and shored up dikes to save several small towns. Says Maj. Shandy Vida (above, at left), "It was great to be able to help our own people."

FLOOD Haunting legacies of loss

CHILLING SIGHT, flood-damaged refrigerators crowd the Grand Forks dump. In neighboring East Grand Forks, Minnesota, a family told their tale of loss with a sign on their home (left)—one of hundreds later demolished to make room for a flood-plain park. Olive Swen's sister, Shelley, helped salvage china (right), but Swen lost her children's keepsakes, "the things you can't replace."

CAROLYN KASTER

FLOOD Slow road to recovery

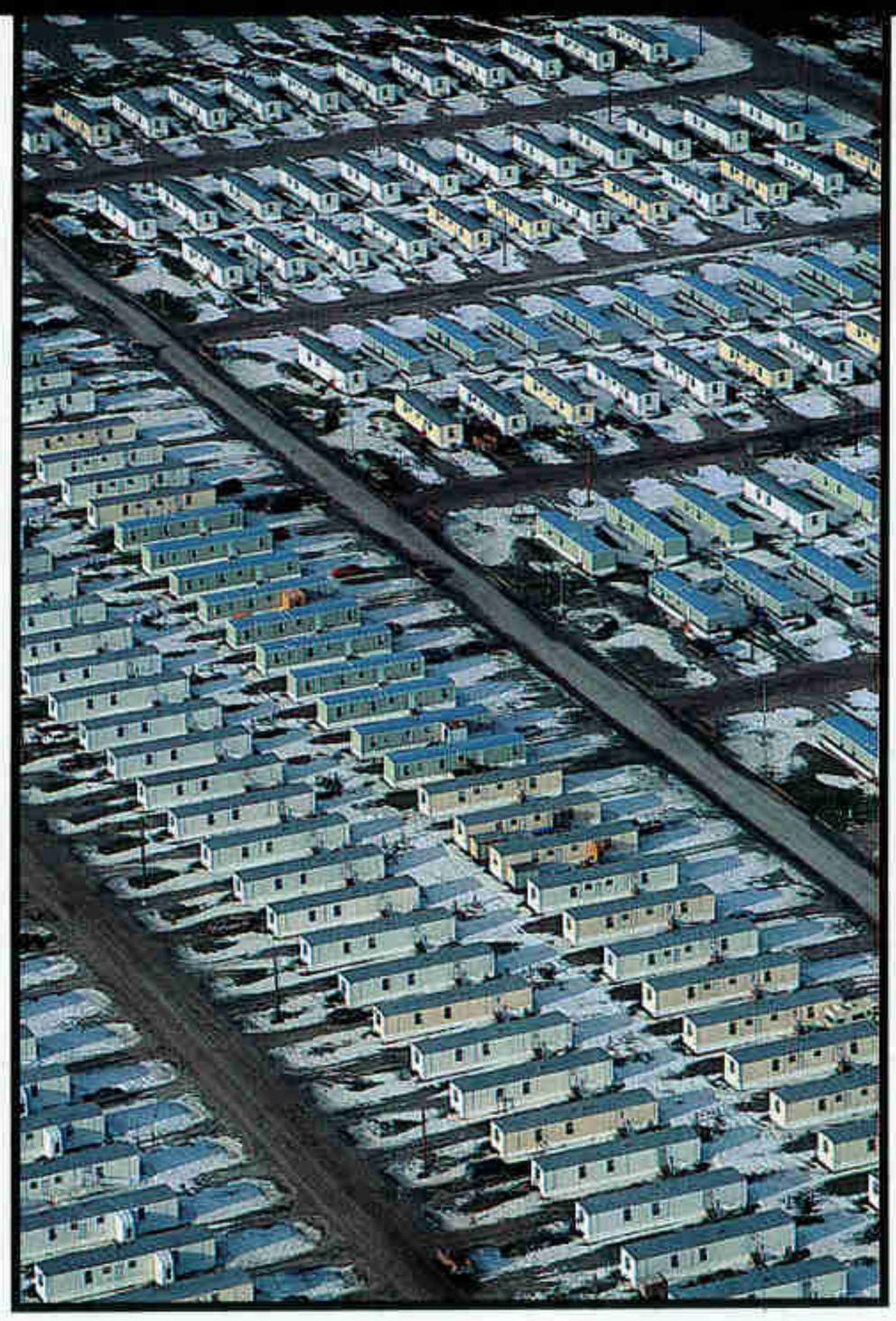
DISPLACED BUT NOT DEFEATED, the Larsons and Vetters move their gutted homes from Sherlock Park in East Grand Forks, now off-limits for rebuilding. They bought ten lots nearby and named the street Sherlock Circle to honor the old locale and attract old neighbors. "We had an area of charm, old trees, and all ages," says Stephanie Larson. "We can't re-create that. But we look at this as an adventure."

time to seek shelter. And scientists at the Los Alamos National Laboratory in New Mexico are now harnessing some of their supercomputers and best minds to predict, through physics, the behavior of disasters like forest fires.

But the choice of whether to heed the warnings remains with human nature.

In many cases preparations have saved lives, and Red Cross officials have told me that for an individual even a little getting ready goes a long way.

"If you've got some water and some food and your family has a plan, then you can still think clearly," said Fred Samuel in Santa Barbara. "If you've done nothing, you panic. You don't even know where your kids are."



IT'S NO PLACE LIKE HOME, but a government trailer park offers relief to hundreds of Grand Forks flood victims. "I've made a couple new friends, and it's been fun," says Andrew Dozhier (opposite). Such resilience may be the most useful tool in repairing the upheavals of nature.

Preparation is, in fact, the reason so many of us get through significant hazards almost routinely. Some Mexicans live comfortably with a level of heat that could kill in Toronto, but when cold milder than a Canadian winter caught thousands of Mexicans unprepared in late 1997, it killed dozens of people. Even vast floods are normal in places like the Amazon, where people have houses on stilts and canoes tied to their porches.

Certainly the increasing costs that both victims and taxpayers pay to recover from disasters show the need for both better mitigation and better preparation. The whole point of the North American effort to map hazards is, after all, to help us learn ways of getting along with them. In order to be safer, we may have to be more willing to acknowledge how unsafe life really is.

Preparation will always clash with our emotions. After a disaster disappears, humans tend to back away from its memories and the lessons it teaches. We do not want to look at what we do not want to see.

Yet the most important thing about ourselves that a disaster reveals is that when it comes, we will handle it—sometimes with panic, sometimes with courage, sometimes with ugliness, and sometimes with magnificent grace.

IN THE STEAMY *suburbs of Acapulco, María Micaela Alcaraz de Castillo stands in the shell of her house, with the backyard washed away and the staircase hanging off the wall in a mess of broken bricks and reinforcing bars. She's washing clothes in a wooden tub. On a post is tied a shard of mirror no bigger than a hand; she still cares how she looks. On the wall, from a nail, hangs a single muddy high-heeled shoe, the only thing she saved from the rubble.*

Micaela comes to this shell every day to wash and cook and give her family meals.

"Why?" says her husband. "It's not a house anymore. It is just a piece of land."

"No," she says. "It is my home."

Micaela stops washing. She describes the flood again and laughs. She looks up at the shoe and gives me that indomitable grin that I have seen on the faces of many people who have faced the disintegration of their lives and realized that though the Earth is stronger than they had ever imagined, so are they.

Micaela laughs again.

"One shoe!" she says. "I ended up like Cinderella." □

Learn more about nature's wild side and share your thoughts online at www.nationalgeographic.com.

lure of the frog-fish

Article and photographs
by FRED BAVENDAM

Undersea eccentric

Brilliant against dark sands, a striated frogfish moves toward a clump of algae, where it will virtually vanish, leaving only the worm-like flesh dangling from its head spine visible to lure prey. Underwater photographers like me search avidly for this wily fish that fishes.

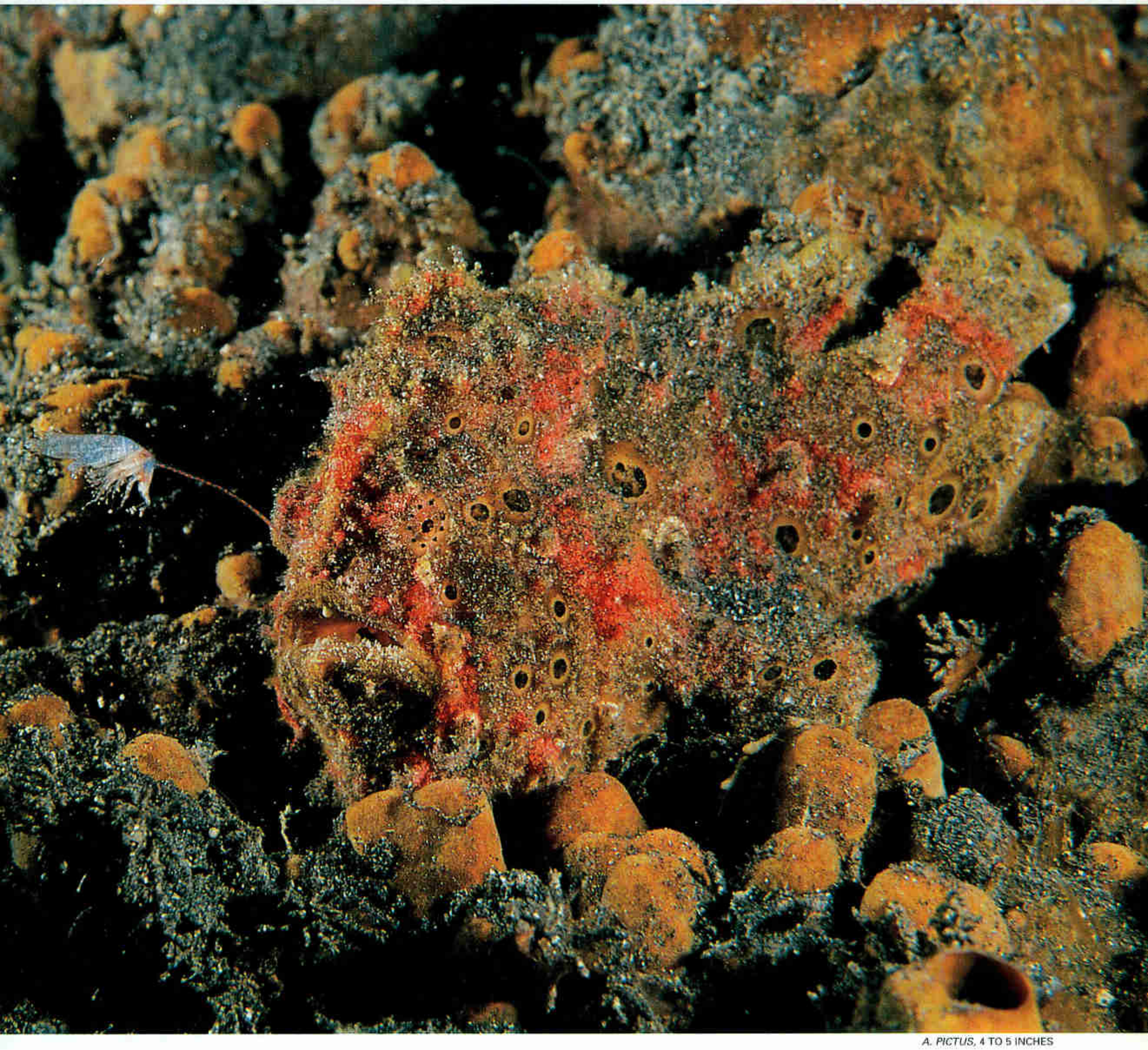
ANTENNARIUS STRIATUS, 5 TO 6 INCHES

three of a kind

While diving in Indonesia last year, I found an astonishing number and variety of frogfish living in algae beds and sponge gardens in northern Sulawesi's Lembeh Strait.

Because of their camouflage frogfish are tough to find and even tougher to identify. For example, the creatures at left and below are painted frogfish found living within a mile of each other, all members of the same species. Compounding the identity problem, most frogfish can change color over periods ranging from a few days to a few minutes.

University of Washington zoologist Theodore W. Pietsch spent 15 years studying frogfish specimens worldwide. He concluded that features such as the structure of the head spine and "lure," or esca, which the painted frogfish below uses like a baited rod to attract prey, are more stable than coloration. Pietsch's work reclassified 165 named species into the 41 frogfish recognized today.



A. PICTUS, 4 TO 5 INCHES

master of disguise

In a rare display of speed, a tasseled frogfish (above) propels itself through open water off Edithburgh, South Australia, with fast flips of its tail fin. The pectoral and pelvic fins of many species seem better suited to walking than swimming, and I've watched frogfish stalk their prey, step by step, across the seafloor.

A poet once wrote of the frogfish, "What softer Skin, and slower Pace deny . . . successful Frauds supply." One secret of their success: Their forehead-mounted lures

closely resemble small prey.

Other tricks include spots, stripes, and fringes that mimic a bed of red algae (right), equipping the tasseled frogfish to ambush its next meal and to conceal itself from its enemies.

RHYCHERUS FILAMENTOSUS, 5 TO 6 INCHES

A. MACULATUS, 4 TO 5 INCHES

A. COMMERSONI, 12 TO 15 INCHES

one big mouth

Faced with a threat, a warty frogfish (left) braces itself on pectoral fins with its mouth wide open, a typical defensive display.

When feeding, frogfish expand the oral cavity even further—to 12 times its normal size—engulfing their prey with a reflex that takes only six-thousandths of a second from start to finish. It's the fastest "gape and suck" of any fish—so fast that other nearby prey may not even notice that one of their number has vanished.

As voracious as its smaller kin, the plate-size Commerson's frogfish (above) will eat a creature twice its length—or even another frogfish.

future

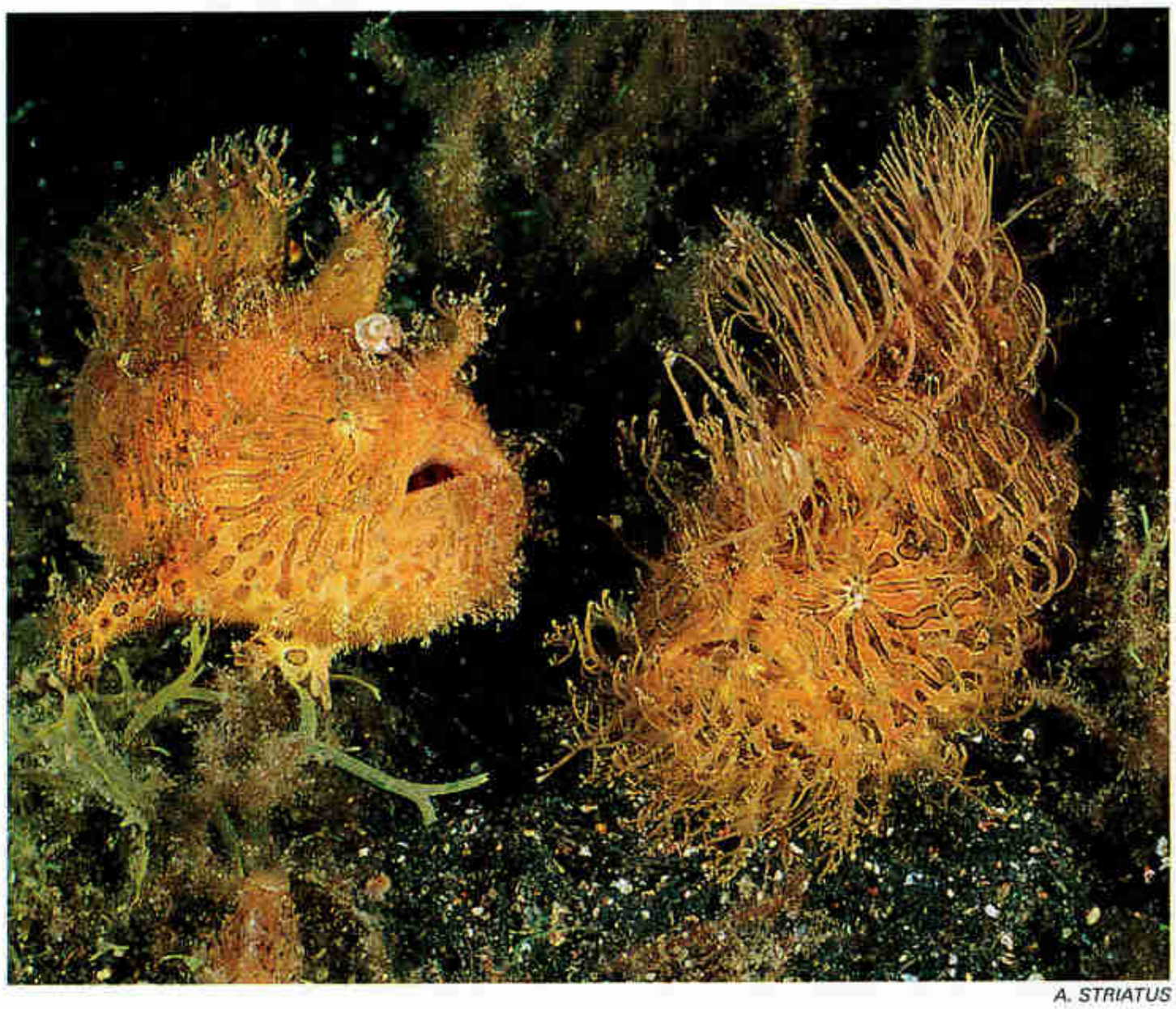
frogfish

Parenting ends with mating for striated frogfish (below). A female releases thousands of eggs in a gelatinous mass that absorbs seawater along with a male's sperm. This fertilized egg raft drifts near the surface for several days and then sinks to the sea bottom as the embryos hatch.

Off Australia's southern coast I found one of the few frogfish that does its parenting differently. The smooth frogfish lays fewer but larger eggs (right) than most frogfish species. One of the mating pair guards the embryos until they hatch—but need never miss a meal. It can feast on would-be predators lured into range by the plump and tantalizing embryos. Its fins-on parenting style probably gives the smooth frogfish a higher offspring survival rate than other species.

Frogfish thrive in tropical and subtropical waters around the globe. Yet this stealthy survivor must still depend on us to protect its ecosystems. □

FRED BAVENDAM has photographed manatees, giant octopuses, and giant cuttlefish for the magazine. His most recent story, on feather star crinoids, appeared in the December 1996 issue.



A. STRIATUS

PHYLLOPHRYNE SCORTEA, 3 TO 4 INCHES

Civilized

By GARRISON KEILLOR
Photographs by SISSE BRIMBERG

Denmark

Warmed by a bonfire and embraces, revelers celebrate Midsummer Eve in Svaneke on the Baltic island of Bornholm. Though not inclined to boast, Danes have a good thing in a nation of liberal values and joyous living—except, perhaps, in melancholy winter.

In a summer reprise of winter's interminable gloom, a storm soaks Copenhagen and pelts cars with windblown bits of broken roof tile. Such days are rare in the golden season when light lingers until 11 p.m., enticing sun-loving Danes outdoors.

Bundled up for holiday shopping, two young Copenhageners face winter's chill on Strøget; at one mile, it is Europe's longest pedestrian street. Fresh-air fanatics, Danes don't hesitate to leave babies alone in their prams for brief periods. Says Copenhagen resident Claus Rørslev Bock, "You can't do that in New York."

DENMARK is a little land of five and a quarter million souls, most of them Andersens, Hansens, Jensens, Jacobsens, or Petersens, with a few Madsens and Mortensens and Rasmussens thrown in for variety, who live on a pleasant green peninsula and two large islands and many tiny ones north of Germany, between the North Sea and the Baltic, a major supplier of ham and cheese and ceramics, a nation of irreligious Lutherans, a democratic society prickly to wealth and privilege and the home of a royal line that goes back to A.D. 935. The peninsula is Jutland; the two islands are Zealand, which includes Copenhagen, and Fyn. A handsome and civilized country, its only wilderness the sea.

The entire country is a little smaller than Lake Michigan, and if it were slipped in there, between Wisconsin and Michigan, it would not be such a bad fit culturally. The same dark humor prevails as in the Midwest, the same stoicism and gentility. It would be a shock to land in a Great Lake, but the Danes would study the situation and work out the best deal they could, keeping their queen and flag, their chirpy language, their generous health and unemployment benefits, their 37-hour workweek, their five weeks of annual vacation plus assorted holidays, their nine political parties (Social Democrats on the left, Radikale in the center, Venstre, or Left, on the right). They might ban the so-called Danish pastry (too gooey). They would make fun of everything American and lambaste our foreign policy. They would see themselves, in every way, as the beautiful swan trapped in the realm of ducks.

Life in Denmark is divided into two parts, the Golden Summer and the Great Murk, which extends from late fall to mid-spring. The months of youth and beauty, when the sky is light until almost 11 p.m. and Danes take to the beaches, eat in their gardens, soak up the sun, feel sleek and smart, and the other months, when they go to and from work in the dark and the rain and just try to keep putting one foot in front of the other and not get too glum.

I used to spend Christmases in Denmark, back when I had connections there, and I remember the night flight over the Atlantic, the

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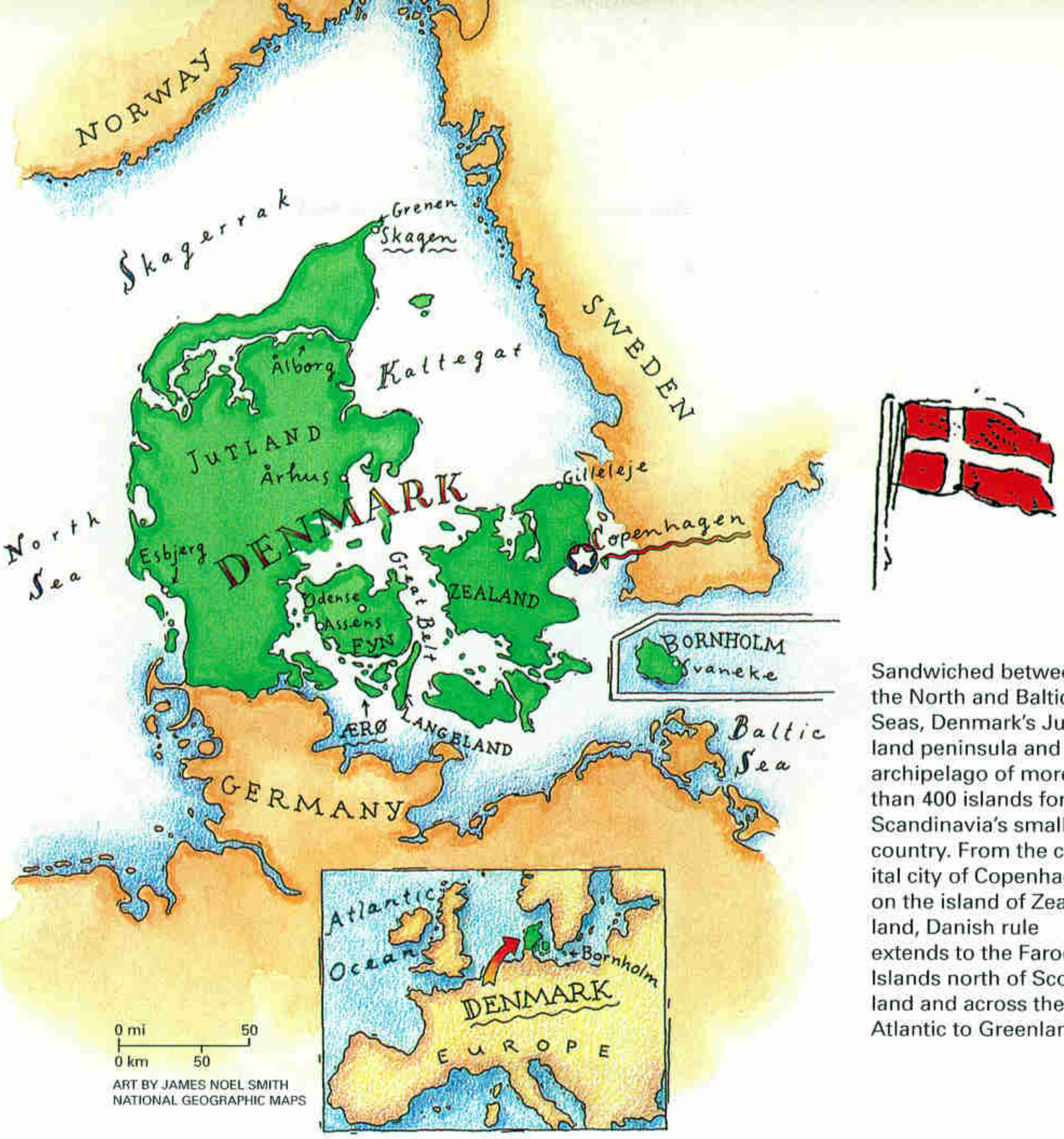
GARRISON KEILLOR, the host of *A Prairie Home Companion* and discoverer of Lake Wobegon, has carried on a long and bumpy romance with the country of Denmark. He admits to speaking Danish well enough to get into trouble but not well enough to get out of it. For former staff photographer SISSE BRIMBERG, a native speaker, portraying her homeland for the magazine has been a long-held dream.



Sandwiched between the North and Baltic Seas, Denmark's Jutland peninsula and archipelago of more than 400 islands form Scandinavia's smallest country. From the capital city of Copenhagen on the island of Zealand, Danish rule extends to the Faroe Islands north of Scotland and across the Atlantic to Greenland.

sun rising to reveal the solid cloud bank below, the descent through cloud to Copenhagen Airport, like coal miners going down into the hole, the pilot putting the wheels down and the ground still not visible, and then, suddenly, red-tile roofs of houses in the mist below, deep green meadows, tree lines, rain trickling across the window, and the wheels bump on the runway, and you're in Denmark, in a gloom so dense you feel it in your skull.

You disembark onto a shopping concourse, and past the mink coats and crystal a sign points you to customs. You parade through, a little surprised at how casually the Danish police glance at your passport. (The man who waves you in may be the last uniform you'll see for a while, Danes being a self-policing people who prefer that authority be inconspicuous.) You collect your bags, and off to the cabstand, the air gray, drizzly, with a tang of salt and smoke.

The cab races off through Amager, past the soccer fields and into the streets of the city, the identical brown-brick apartment buildings, the mustard stucco houses, passing a stream of bicyclists pedaling solemnly to work in their bright red or yellow slickers. Danish jumps out at you from signs, lots of cognates here: A drugstore is an *apotek* (remember apothecary), and a merchant is a *handler*—a *boghandler* sells books, a *vinhandler* wine—a *restaurant* is a restaurant, and you realize that you won't starve here or get lost.

Sober-faced Danes queue at the bus stop in the rain, which they do not flinch at, and it dawns on you that a daylong rain is not unusual, this is a North Atlantic winter. The sun won't shine tomorrow, maybe not the next day. You have arrived in a land where Christmas means more than in, say, Barbados; it is the last outpost on the long grim trek toward spring. Dark gray sky at noon, dull brown brick all around, dead trees, broken glass in the gutter, and you, sorry you, your head like a sponge full of mud. At first you think it's jet lag, and then you realize that everyone else feels this way too.

Welcome to the birthplace of existentialism.

The taxi brings you over the canal and into the heart of Copenhagen, the grand old city that has resisted freeway and high-rise in defense of its narrow, twisting brick streets from medieval times, its skyline of green church steeples, its pretty squares and fountains. Past the Christiansborg Castle where parliament sits, past the big department store, Magasin, and the Royal Theater hulking on Kongens Nytorv, a plaza faced by stately old piles, and up a narrow street called Bredgade (Broad Street), past the queen's palace at Amalienborg, and up to Østerbro, where I once lived, in a big echoey belle epoque apartment on Trondhjemsgade. The dining room had a 14-foot ceiling with plaster moldings, and when I sat in it, writing, it felt as if I were drafting the Treaty of Ghent.

We celebrated Juleaften there every December 24. My stepchildren and I trudged through the late afternoon mists to Trinitatis Kirke, where little Søren Kierkegaard attended confirmation class, the church the Round Tower is attached to. It was packed to the rafters Christmas Eve with shiny children and their *mors* and *fars* and *mormors* and *morfars* and *farmors* and *farfars*. We sang the old Danish carols and heard a sermon about our obligations to the Third World and hiked home to our pork roast and caramelized potatoes, and the oldest boy lit the candles on the tree in the dining room and threw the doors open, and we looked at it and gasped—every year the same gasp—and ran hand in hand through the dark rooms singing, "*Nu er det jul igen,*" and opened our gifts.

The 25th is an afterthought, a quiet day for recuperation; Christmas Eve is the great night of the year. And on Nytårsaften, the 31st, you sit down at 6 p.m., along with everyone else in Denmark, and watch Queen Margrethe deliver her annual homily to the people. It lasts about 12 minutes and ends with her greetings to the people of Greenland and the Faroe Islands and to the people who work on the sea. "Heartfelt greetings from the prince and me," she says, beaming. "God bless Denmark." And then everybody proceeds to get a little drunk, or maybe a lot. At midnight Danish television plays the romantic national anthem, and you stand, champagne in hand, and sing it, reading the words off the screen. At 2 a.m., to clear your head, you go for a walk. Blocks and blocks of five-story brick houses; gray, white, cream, blue, gold candles flickering in the casement windows; the steep red- or black-tile roofs, the forest of chimneys, dormers in the garrets; and you feel the romance of Copenhagen, as if walking into an old painting, the enchantment of darkness and rain and the warm hearth that you eventually will walk back to.

I HAD SEEN enough Danish Decembers to hold me for a while, so I flew over last year in June for a week of summer. I looked around Århus, the handsome harbor city with a forest next to its downtown, and had dinner with Brian, a poet friend and iconoclast who loves to drink whiskey and disparage the monarchy and the church. "Brian is one of those English names—Tommy, Johnny, Brian—that working-class parents favored after the war," he said. "It's a ruffian's name. If there was a Brian in a class, the teacher would smack him on the first day and get it out of the way."

I drove up to Skagen, where the turn-of-the-century artists Michael and Anna Ancher and P. S. Krøyer painted fishermen and garden parties and ladies in white strolling along a beach under the midnight sun. I took the train to Fyn for Midsummer Eve. I visited Gilleleje, the vacation village on the north coast of Zealand from which, to escape the Germans in October 1943, Danish Jews were smuggled by fishing boat over the sound to Sweden. I swam in the sea there with friends, which I wasn't going to do, being skittish about nudity and knowing how cold the water is, until my friends said, "Of course, you don't have to if you'd rather not," and then, of course, I had to.

And I hiked around Copenhagen, along earthworks and remains of moats and along the pier where cruise ships tie up, to the statue of the Little Mermaid, sitting on her rock, looking small and forlorn, and beyond her to the magnificent fountain of Gefion, the

goddess at the plow, lashing her oxen, water spraying from their nostrils, and great plumes arching up from the plowshare. I sat at outdoor cafés in Gråbrødretorv and Kultorvet and spoke my pitiful rusty Danish to waiters and ate my herring and studied the passersby. Danes are good to watch. They keep a stolid public expression, like Buster Keaton, and are masters of the raised eyebrow. Let a waiter drop a tray of dishes and looks of deadpan amusement flicker on every face, including the waiter's. I step into a bakery, and when the girl behind the counter says, "*Goddag,*" I say, "*Goddag, jeg vil gerne ha' to lille stykke boller,*" and her left brow lifts and she says, "Oh, you want two of these buns?" "*Ja, tak,*" I say. "You speak Danish well," she says. "Where in America are you from?"

I am stopped by a young woman in jeans and a cutoff top who asks where to catch the train to Deer Park. A major thrill for me, to be asked for directions by a Dane, in Danish, and I tell her in Danish where the S-train station is, and add, "And thank you for your navel." It is a very handsome navel. She covers it in mock modesty and murmurs, "It was a gift from my mother."

In a café near Kultorvet, I used to sit every week and drink coffee with Fradley Garner, an émigré who speaks Danish with a New York accent to his grandchildren. "No matter how much you like Denmark, it's good to get together with someone who knows who Joe DiMaggio is," he told me once.

In another café I would have lunch with my friend Elly Petersen, a tall, aristocratic lady of 74 when I met her on my first trip there in 1985 and she told me about her flaming youth, dancing to American jazz in the clubs of Nørrebro. We sometimes had oysters and champagne, what she called "the Karen Blixen lunch," but usually we ordered the classic: herring on rye bread with a shot of aquavit, and then another shot, followed by a fish fillet with a glass of beer, and then a slice of roast pork with the rind on, and a slab of blue cheese for dessert, and coffee.

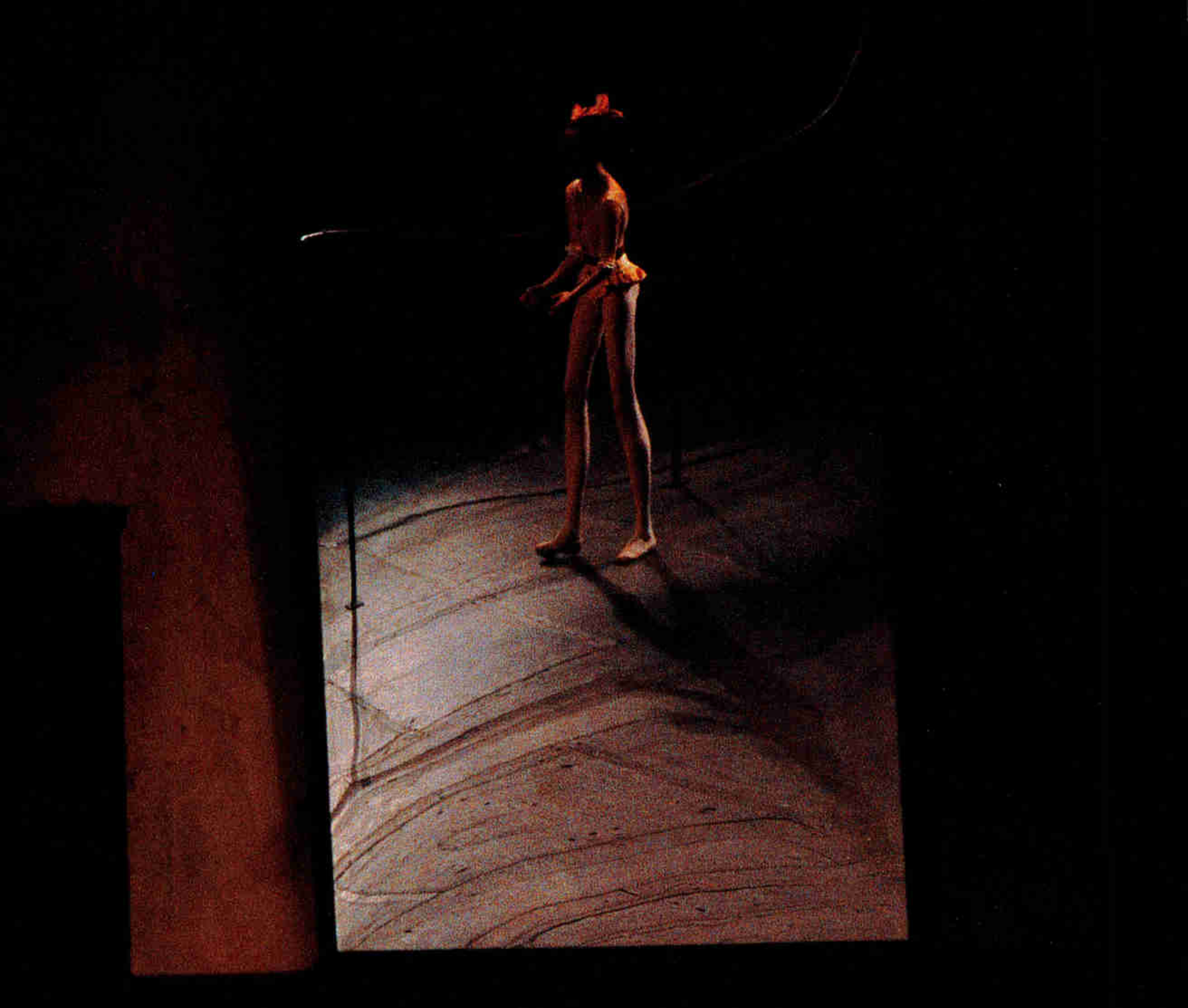
Elly had met Victor Borge, she said, in 1937 in a dance hall called Zigeunerhallen on Jagtvej in Nørrebro when he was still Borge Rosenbaum and played piano in a jazz trio. Once she had danced with him. "Really," she said. "I did." Rosenbaum was a Jew and wrote satiric songs about the Nazis and, on the verge of arrest in 1940, he caught a boat to Sweden, Elly told me. And a few months later he snuck back home to visit his mother, who was dying. He sat by her bed and told her a sweet lie; he said, "Mama, I'm going to Hollywood and get into the movies, and when I do, I'll send for you, and we'll live in California in a big house with a swimming pool." And she said, "Borge, don't let it go to your head."

Back when I knew Elly, I aspired in a modest way to dress, smell, walk, and speak Danish, and she corrected my pronunciation, so I would sound more like the queen, less like a yahoo. I remember exactly when my Danish reached its high-water mark: It was late one night after a one-month total-immersion course at Askov Folk High School, in the corn belt of Jutland, when a fellow student and I sat in a tavern jabbering away, and after 15 minutes or so he suddenly stopped and said, "*Hvor kommer du fra?*" and I said, "*Minnesota, naturligvis,*" and he laughed and said, "*Jeg er en Texan.*" Born and bred in Dallas, but he had a good accent. We continued, in Danish, talking about what we loved about Denmark—the white stone churches, the golden barley fields, the shadowy beech forests, the good humor of daily life, the calmness of the people, their social grace, their eternal, untiring tolerance.

It is—let's be frank here—almost everyone's idea of the World's Most Nearly Perfect Nation: a clean, peaceful, well-regulated society populated by prosperous (but not greedy or rapacious), tolerant (but principled), law-abiding (but humorous), computer-literate, bi- or trilingual people who all vote in elections and are as witty as Victor Borge and have no hang-ups about sex and reside in sunny, energy-efficient homes, the decor running toward light woods and primary colors, who can discuss (in excellent English) the infrastructure needs of developing countries or the Danishness of Woody Allen while serving perfectly poached salmon off handsome *(Continued on page 64)*

Lacy trees of Copenhagen's Nyhavn district, where Hans Christian Andersen lived, came to no fairy-tale ending: Elm disease recently killed them. Once a haunt for sailors, the 17th-century buildings still attract all comers to a mix of lively shops and restaurants.

Mirrors and madness distort characters in the Royal Danish Ballet's production of The Lesson, *the allegory of a sinister dance master who dominates his students. Denmark's largest professional ballet company performs around the world to international acclaim.*



earthenware, copies of which are on display at the Museum of Modern Art in New York City.

Despite Denmark's manifest virtues, Danes never talk about how proud they are to be Danes. This would sound weird in Danish and violate their pride of modesty. When Danes talk to foreigners about Denmark, they always begin by commenting on its tininess, its unimportance, the difficulty of its language, the general small-mindedness and narcissism and self-indulgence of their countrymen, the high taxes—52 percent is the average income tax rate, and there's a 25 percent sales tax. No Dane would look you in the eye and say, "Denmark is a great country." You are supposed to figure this out for yourself.

It is the land of the silk safety net, where almost half the national budget goes toward smoothing out life's inequalities, and there is plenty of money for schools, day care, retraining programs, job seminars—Danes love seminars: Three days at a study center hearing about waste management is almost as good as a ski trip. It is a culture bombarded by English, in advertising, pop music, movies, the Internet, all the chic media, and despite all the English that Danish absorbs—there is no Danish Academy to defend against it—old dialects persist in Jutland that can barely be understood by Copenhageners. It is the land where, as the saying goes, "Few have too much and fewer have too little," and an American is struck by the sweet egalitarianism that prevails, where the lowliest clerk gives you a level gaze, where Sir and Madame have disappeared from common usage, even Mr. and Mrs., and children address teachers by their first names. It's a nation of recyclers—about 55 percent of Danish garbage gets made into something new—and no nuclear power plants: The Danes prefer windmills. It's a nation of tireless planners. Trains run on time. Things operate well in general. Only 2 percent of the national budget goes to police and prisons and courts, and 3 percent to defense. It is a famously peace-loving country, whose troops, part of the UN peacekeeping force in Bosnia, engaged Serbian militia in a firefight in April 1994, the first official Danish act of war since 1864.

Such a nation of overachievers—a brochure from the Ministry of Business and Industry says, "Denmark is one of the world's cleanest and most organized countries, with virtually no pollution, crime, or poverty. Denmark is the most corruption-free society in the Northern Hemisphere." So, of course, my heart lifts at any sighting of Danish sleaze: skinhead graffiti on buildings ("Foreigners Out of Denmark!"), busted beer bottles in the gutters, drunken teenagers slumped in the park.

Last summer in Odense, two blocks from the Hans Christian Andersen birthplace museum, my car was broken into and a billfold stolen; around the corner from the crime scene was a wooded area littered with garbage, where gaunt figures sat shooting up heroin. I enjoyed telling Danish friends about this for days afterward. When they expressed chagrin, I said, "Hey. No problem. We have crime in America too."

NONETHELESS, it is an orderly land. You drive through a Danish town, it comes to an end at a stone wall, and on the other side is a field of barley, a nice clean line: town here, country there. The stores close at six, even earlier on Saturday, and on Sunday you window-shop; an American has to learn that sometimes you just plain can't have it. It is not a nation of jaywalkers. People stand on the curb and wait for the red light to change, even if it's 2 a.m. and there's not a car in sight. The red light is part of the system: You cross against it, and you are showing disdain for your countrymen. (I feel sheepish waiting for the red light, so I cross, and several times I discovered that Danish drivers don't slow down for jaywalkers. They don't see you in the crosswalk because you're not supposed to be there.)

Danes don't think of themselves as a waiting-at-2-a.m.-for-the-green-light people —that's how they see Swedes and Germans. Danes see themselves as a jazzy people, improvisers, more free spirited than Swedes, but the truth is (though one should not say it) that Danes are very much like Germans and Swedes. Orderliness is a main selling point.

It is the land where, as the saying goes, "Few have too much and fewer have too little," and an American is struck by the sweet egalitarianism that prevails, where the lowliest clerk gives you a level gaze, where Sir and Madame have disappeared from common usage, even Mr. and Mrs., and children address teachers by their first names.

Denmark has few natural resources, limited manufacturing capability; its future in Europe will be as a broker, banker, and distributor of goods. You send your widgets by container ship to Copenhagen, and these bright, young, English-speaking, utterly honest, highly disciplined people will get your widgets around to Scandinavia, the Baltic States, and Russia. Airports, seaports, highways, and rail lines are ultramodern and well-maintained. There is a presumption of punctuality here. An American train leaves the station if all the members of the Departure Committee can find no reason for it to wait; the Danish train leaves the station unless someone throws himself across the track and he happens to be someone they like.

Daily life turns on predictability. If the timetable says that the train leaves Klampenborg at 7:06 and arrives at Østerport Station at 7:27, those times are reliable, and if you invite Jens and Camilla for dinner at 7:30, that's exactly when they'll knock on your door, not two minutes later. And when you open the door, they will expect that you too have managed your time and are not racing around snatching up dirty socks, that dinner is under control, the candles lit, the wine chilling, the hosts prepared to be congenial.

To Danes this is a sensible way of life, and to an American it seems marvelous at first, and then it strikes you as stifling. Weird, even. You meet Danes who have their lives planned in quite some detail for years in advance and derive comfort from this. You see how stability is cherished. You meet an old married couple, both teachers, who keep their finances separate, and the wife says, "I would love to visit America next summer. Ole is going, but I can't afford it." To an American, this is perverse. They love each other. Why can't Ole just pay her way? Because that is not how those two do things, that's why.

A few years ago, walking along Store Kongensgade in Copenhagen before Christmas, I passed a building gutted for renovation and looked in the cellar window, and there, on a dirt floor, surrounded by piles of lumber, were three long tables covered with white cloths and set for a meal, a Christmas centerpiece on each table, with candles and little Danish flags, and at each place setting, silverware, a glass for aquavit, a glass for beer, a china plate, a napkin. The construction workers were about to enjoy their traditional Christmas lunch, with proper china and silver, with the herring and aquavit, the requisite toasts and speeches, and by the time the apple fritters were served, they'd be in a mood to sing Christmas songs, and you knew exactly which ones they'd sing.

I told a Danish friend, "If American workers held a Christmas party, they would go to a restaurant." And she said, "Why should they be ashamed of where they work?"

The orderliness of the society doesn't mean that Danish lives are less messy or lonely or angst-ridden than yours or mine, and no Dane would tell you so. You can hear plenty about bitter family feuds and the sorrows of alcoholism and about aimless, overindulged

young people working the system to make a cushy life for themselves and perfectly sensible people who went off one day and killed themselves. An orderly society can't exempt its members from the hazards of life.

But there is a sense of entitlement and security that Danes grow up with and Americans don't. Certain things are yours by virtue of citizenship, and everyone knows what they are, they're the same for everyone, and you shouldn't feel bad for taking what you're entitled to, you're as good as anyone else. A woman in Hørsholm, who had lived in California as a child, told me: "I miss people I knew in America, how open and friendly they were, but it's better to have a safety net under you. You might not have a chance to do big things, but nothing so bad will happen to you." The rules of the welfare system are clear to everyone, the benefits you get if you lose your job, the steps you take to get a new one; and the orderliness of the system makes it possible for the country to weather high unemployment and social unrest without a sense of crisis.

There is social unrest in the World's Cleanest and Most Organized Country—which is, to an American, certainly interesting, considering how Danes once lectured us about racial intolerance, but never mind that. Now you hear them discuss the country's troubles with its Yugoslavian and Turkish guest workers, who came 30 years ago when the country needed cheap labor, and today the guest workers' children, Danish-born, Danish-speaking, Muslim, are discriminated against because they have the wrong last names. Protest demonstrations flare up in the Muslim ghettos of Ishøj, and right-wing politicians have seized on the issue. But I never heard the problem described as intractable: Everybody seemed to think it would get worked out eventually.

Denmark is the stable society it is because it is productive and prosperous, and because Danes get a similar start in life, whether you grow up in the mansions of Hellerup or the tenements of Nørrebro. At birth you become a member of the Lutheran Church. (You can petition to get out, but it's no simple matter.) You go to similar day care centers, toddle off to the same kindergartens, then to a *folkeskole* for grades one to nine, where, in the fourth grade, you begin the serious study of English (in seventh, German or French). There isn't Public School 10 for the poor and St. Cuthbert's-on-the-Hill for the mill owner's children; everybody goes down the same road. In the spring of ninth grade you reach the great divide and find out if you go to *gymnasium* or a technical school or a business school for late bloomers. Gymnasium is for the serious student, no troublemakers, no slackers, no goofballs. About 40 percent wind up there. At the same time the state starts paying you a stipend of up to 1,800 kroner a month ($260), depending on your parents' income. It's meant to even up the odds a little more.

After three years of gymnasium you take the test that pretty much decides your career, the *studenter* exam. Admission to various colleges and professional schools is by bidding, high studenter scores get first dibs. It takes a very high score to get into the humanities, medicine, dentistry, or psychology—a lesser score to major in math or physics or chemistry or theology. On the other hand, to become a midwife (in Danish, "earth mother") takes a very high score, it being a popular career. So the woman in blue scrubs who tells your wife to take a deep breath and push hard may be a good deal brighter than the guy in the pulpit who explains the parable of the vineyard.

MY LAST DAY in Denmark I took the Inter-City Express from Copenhagen to the island of Fyn for Midsummer Eve at the house of old friends, a teacher and his wife, a writer. The train no longer switches onto a ferry for the trip across the Great Belt; it slips into a tunnel and races under the sea and up to an island and over a bridge, the longest rail-auto bridge in Europe, 6.6 kilometers long, one of a series of bridge and tunnel links that will knit Denmark together and tie the country to Sweden. My friends, Britt and Torben, met me at the station, and we drove south to their house.

I said I missed the train-ferry, and they said

they had mixed feelings about it. "But then we Danes love to hold two opposing views at the same time," said Britt. "That's probably why there was no referendum on the bridges, because the people might have voted against them, out of sentiment, even though everyone knows they're necessary. We can't think of ourselves as an island anymore. But we still do."

The car wheeled south, through the rolling paradise of Fyn, and we talked about the Danish love of paradox—the tendency to strive to get ahead and to deny that you are doing any such thing. To belong to the Lutheran Church and yet never attend except at Christmas. ("Actually," said Britt, "attendance is up a little. You see 14-year-olds coming in to be baptized, sometimes over their parents' objections. Anyway, there are more coming in than going out.") The paradox of a highly secular society—no Dane running for office need make any public show of religious faith whatsoever, in fact it would be taken as bad taste—and yet Danes take Easter as a holiday and Maundy Thursday and Good Friday and Easter Monday, plus three days for Christmas, and Whitmonday, and something called Great Prayer Day in April. "Well, that's just us," said Britt.

Danes have belonged to the European Union since 1973 and still, down deep, feel opposed to it, she said. "We are terribly offended by our bureaucrats who go to Brussels to work for the EU and earn more than their counterparts here, fly first-class, live in luxury apartments—at least, we think they're luxurious. We're funny that way. If 90 Danes were living the high life in Brussels, or if we thought they were, we might very well vote Denmark out of it."

Britt and Torben's house is an 18th-century stone house on the outside, modern on the inside, old casement windows with thermal panes, an antique ship captain's table with a computer on it, by which Torben exchanges e-mail with me. Shelves full of books, dozens of American novels, Cheever, Updike, Hemingway, Paul Auster. The house looks down a long slope of meadow toward the sea, the island of Langeland in the distance, and the island of Ærø, the name of which I am one of the few living Americans to pronounce almost correctly, they told me. I was so proud, I tried to work Ærø into the conversation all evening. Even if I barely understood what the conversation was about, I said, "Would this also be true on Ærø?"

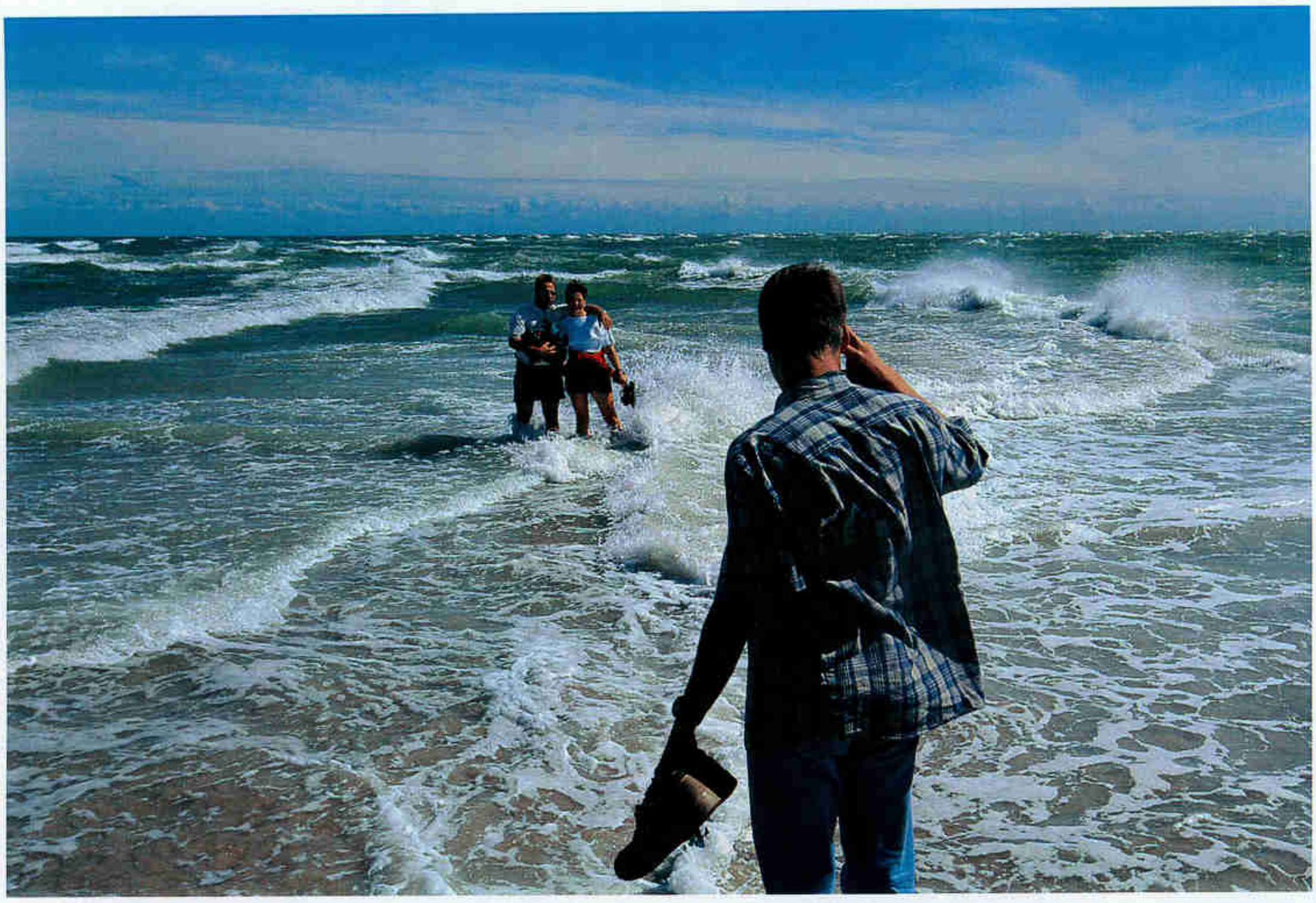
There were 30 guests milling around in the backyard when I arrived, and a few minutes later we took our seats at two long tables in the backyard. Torben raised his glass and welcomed everyone and said, *"Skål. Velkommen."* And we sat down to shrimp salad and poached salmon and lamb and red wine and very good bread.

The dinner included long toasts, to the queen and to America and to one another, and there were songs about the beauty of the Danish landscape and Hans Christian Andersen's hymn that begins, "In Denmark was I born, there I have a home; there is my root, from there my world begins. O you Danish tongue, you are my mother's voice, how sweetly you bless my heart." Every time I looked around, I saw people smiling.

THE SKY WAS STILL AGLOW at eleven, when we hiked down to the shore where Torben had laid a ten-foot-high tepee of lumber and kindling for the bonfire. His sons trooped down from the house, bearing a life-size straw witch on a pole. She was decked out in a dress and hat and shoes and stockings and riding a broom. "Those are my and your mother's clothes!" cried Torben in mock dismay. They propped up the pole in the lumber and put a match to the wood, and we sang hymns to Denmark and summer as the blaze licked at the witch's skirt and she went up in flames.

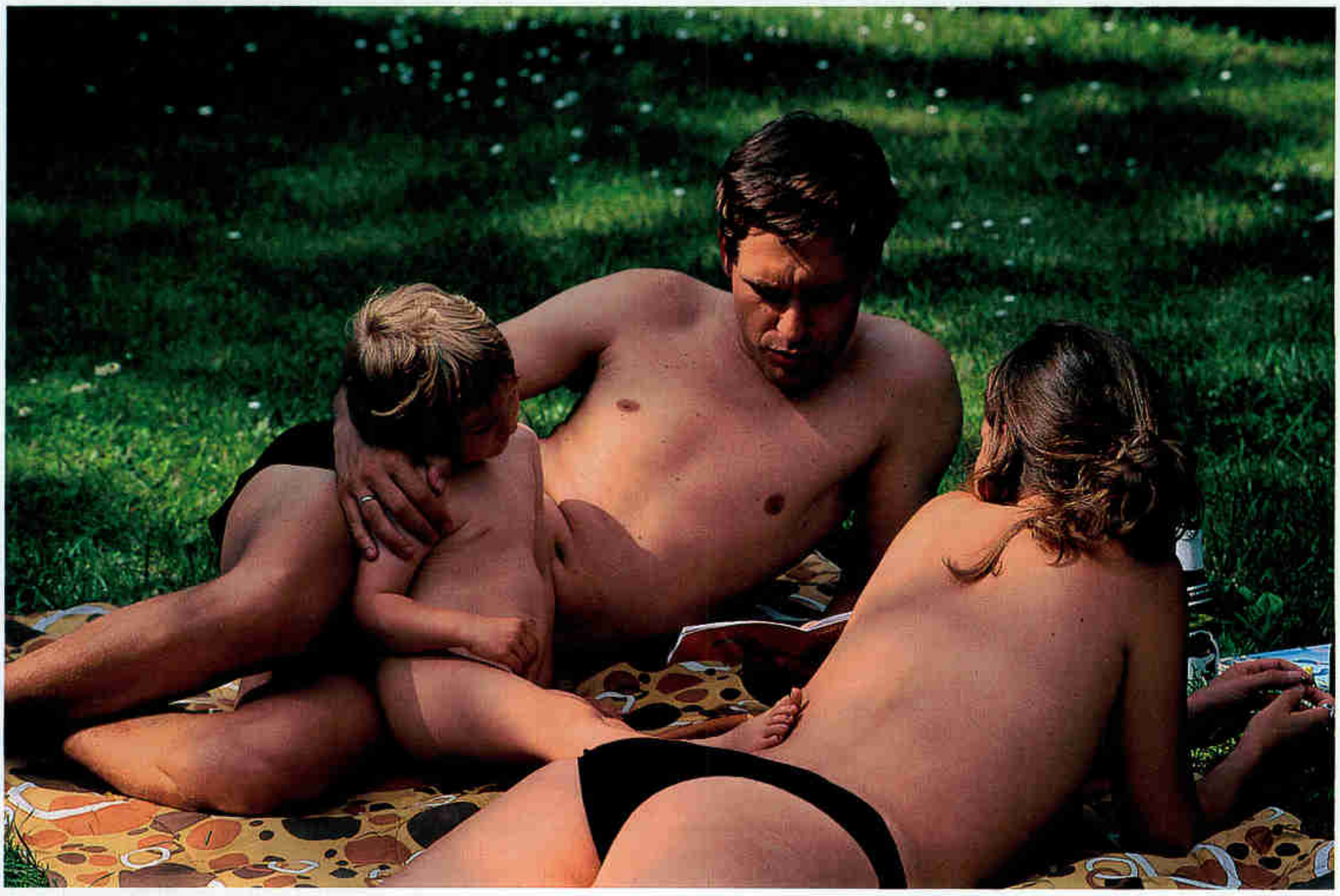
You could see, up and down the shore, bonfires for miles. Everyone in Denmark seemed to be outdoors, busy banishing evil spirits from the land. When the fire burned down, the boys and men took turns leaping over the embers. We went up to the house for coffee and cake, and I climbed the stairs to bed about the time the sky was turning light again. It was a wonderful party, one of the best. It is hard not to love a country that brings up its people to do this.

Vintage vessels in an annual regatta grace the dock at Assens on the island of Fyn. In the seagoing tradition of the Vikings, such schooners in the early 1900s traded dried cod from Newfoundland for salt from Spain and Portugal.



Knee-deep in danger, visitors wade into the riptide at Grenen, the northernmost point of the Jutland peninsula. On drier ground in Copenhagen, a tangle of bicycles attests to a national mania for cycling. Danes mount two-wheelers to keep fit and reduce air pollution, making the most of their country's nearly flat terrain.

"I just yell, 'Police!' and they wriggle into costume and go," says 78-year-old Peter Cibrino of his trained rats, stars of a show he has taken on the road for 60 years. Breaking from their own rat race, a Copenhagen family spends a quiet interlude outdoors. A relaxed attitude toward nudity has long been a part of Danish life. Says one Dane, "We don't shock easily."



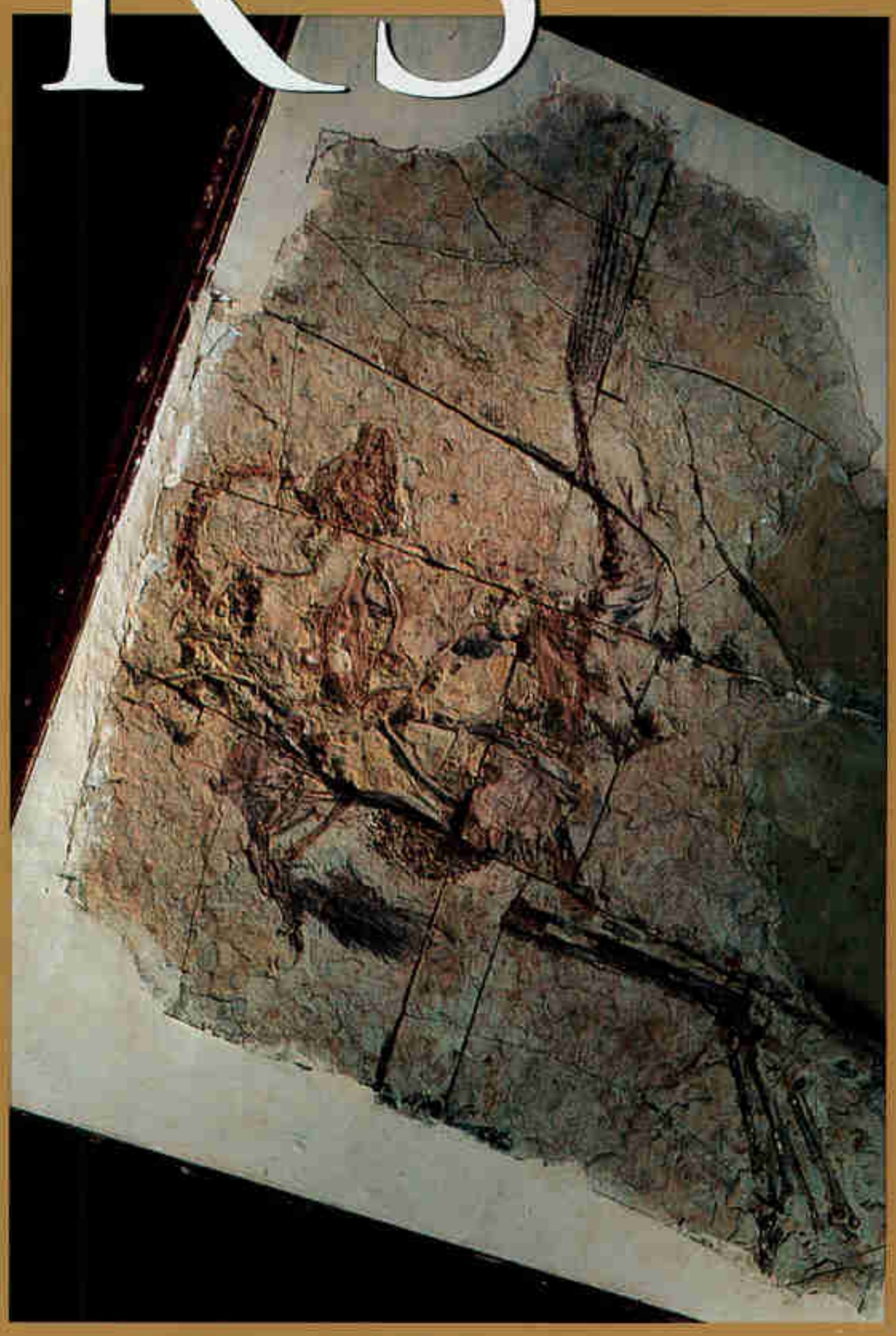
Enjoying the bounty of a field left fallow to renew the soil, Susanne Carlsen picks wild poppies on Bornholm, Denmark's easternmost island. Her daughter, Evalu, can look forward to a lifetime of safety and comfort in a country where caring and equality blossom together. □

DINO TAKE

New Fossil Finds From China Provide Clues to the Origin of Birds

By JENNIFER ACKERMAN
Photographs by O. LOUIS MAZZATENTA
Art by PORTIA ROLLINGS
Models by BRIAN COOLEY

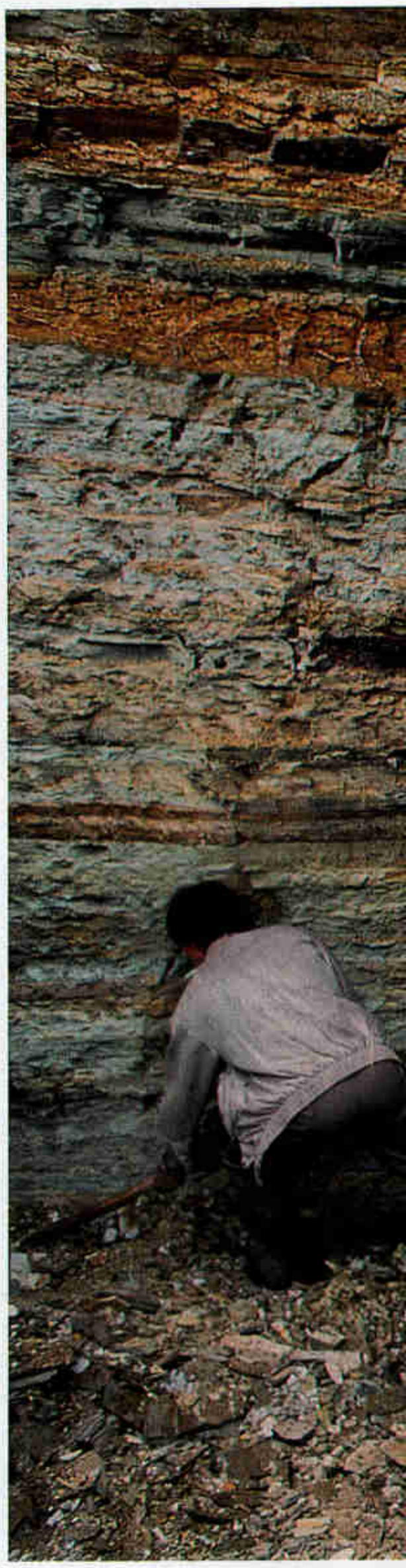
SAURS



Caudipteryx zoui

Posed in courtship display, a model depicts a creature nearly three feet long that stunned paleontologists when resurrected from its stony grave—a dinosaur with feathers. This plumage appears on the fossil (above) at the end of the tail, at top, and under the arm, at lower left. More than 120 million years old, *Caudipteryx zoui* and three other new fossil species from China support the thinking of most scientists: Birds descended from dinosaurs, a lineage illustrated on pages 90-91.

WING



Storm clouds evoke the volcanic ash that repeatedly coated China's Liaoning Province during the early Cretaceous period, helping create a fossil-laced formation of an archaic lake bed at Sihetun (right). Months before the discovery of *Caudipteryx,* farmer Li Yin Fang, second from right, found another startling creature, given the name *Sinosauropteryx prima*.

ONE SUMMER DAY Ji Qiang received a green silk box from a fossil dealer in Liaoning, a far northeastern province of China. Ji, the director of the National Geological Museum in Beijing, suspected that the box contained an ancient fish or reptile—Liaoning is rich in lake bed fossils dating from more than 120 million years ago. But when Ji opened the box, he gasped.

Inside was a creature unlike any he had ever seen. It was about the size of a chicken, frozen as if in mid-stride with its head wrenched back. It had a large skull with needle-sharp teeth, a pair of short, stout forelimbs, and a bony tail nearly double the length of its body. So well preserved was the creature that Ji could see not only the fine details of its skeleton but also its soft tissue and other body parts that usually do not fossilize.

"The fossil looked a lot like a small meat-eating dinosaur," Ji told me, "except for one thing." Along its back, from neck to tail, ran a thin, dark ridge of fibrous lines. To Ji the tiny filaments bristling the animal's neck, the longer fibers furrowing its back and tail, signaled not just one more diminutive dinosaur but a startling new clue to one of evolution's greatest mysteries: the origin of birds.

For generations scientists have been puzzling over where birds came from. Did they arise from dinosaurs? If so, which ones? And where are the missing links between dinosaurs of the deep past and today's finches and warblers? Ji wondered: Could this new fossil, *Sinosauropteryx prima*, or "first Chinese dragon feather," be just such a missing link? Could those strange fibers be the earliest examples of bird feathers?

JENNIFER ACKERMAN, the author of *Notes from the Shore*, is working on a book about evolutionary biology. She is a fellow at Radcliffe College's Bunting Institute. Photographer LOU MAZZATENTA is a former NATIONAL GEOGRAPHIC senior assistant editor. Artist PORTIA ROLLINGS is a staff illustrator at the American Museum of Natural History in New York. Canadian sculptor BRIAN COOLEY has created nearly three dozen life-size dinosaurs ranging from embryos to *T. rex*.

The very traits that define birds, especially feathers and thin, hollow bones, make for scarce fossil remains, bedeviling those seeking clues to the origin of birds and avian flight. So rare are the conditions that preserve bird remains—sediments devoid of oxygen and composed of grains so fine they protect the details of delicate feathers and bones—that only a few localities have yielded early bird fossils, tiny windows to the long, dark avian past.

But a burst of new finds from around the globe in the past two decades has quickened the pace of discovery: flightless creatures the size of wild turkeys that wandered the steppes of Central Asia 80 million years ago and tiny skilled fliers from Spain more than a hundred million years old sporting wings nearly as sophisticated as those of modern birds. And now from China *Sinosauropteryx* and two astonishing new creatures with feathers—as well as a flock of ancient birds so beautifully preserved you can see every detail of their skeletons, beaks, claws, and feathers.

News of the Chinese finds has fired up hot debate over the twigs and branches of the avian family tree. Most scientists place *Sinosauropteryx* squarely on an early branch linking dinosaurs and birds. But a few others still doubt the dinosaur–bird tie, holding that the avian clan evolved from some *(Continued on page 84)*

The First Dinosaur With Protofeathers?

Sinosauropteryx prima

"First Chinese dragon feather," as its name translates, was found at Sihetun in 1996 and named for filaments thought to have covered its body. Most visible here as dark streaks rising off the hips toward the tail, these filaments may have been protofeathers from which avian flight feathers evolved.

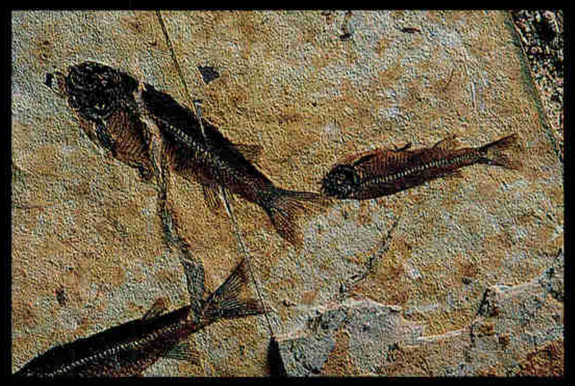
Sealed at death more than 120 million years ago, the eye of a juvenile *Sinosauropteryx* glints with black carbon that crystallized during fossilization. If growths on the head and neck were primitive plumage, they may have served to trap body heat or for courtship display. *Sinosauropteryx* has been classified as a theropod, a meat-eating dinosaur.

The only dinosaur yet found with a mammal in its gut, the specimen exhibits its last meal behind the ribs near the thigh bones (red outline). A close-up (right) pinpoints the toothed jawbone of the unidentified prey.

Fossil Bonanza

Hopes for another big discovery draw scientists to the dig at Sihetun, where layers of rock entomb birds, dinosaurs, plant life, and multitudes of fish, including *Lycoptera* (right). Dating from more than 120 million years ago, the lake bed formation is a hundred feet thick and covers 20 square miles. Legitimate excavators compete with unsanctioned diggers, who, despite the efforts of local authorities, still remove fossils to sell on the black market.

As if felled in mid-stride, a *Sinosauropteryx* (fossil at right)



hoists a flexible tail with 64 vertebrae—the longest tail of any known theropod—probably used for balance. Such features shrank as some dinosaur species became ever more birdlike.

A pair of oval mounds, possibly eggs lodged within the oviduct, lie inside the lower rib cage of a *Sinosauropteryx* fossil specimen.

The downy filaments of *Sinosauropteryx* measure as long as 1.5 inches but lack aerodynamic quality. Such material is so fragile that it is rare to find it well preserved.

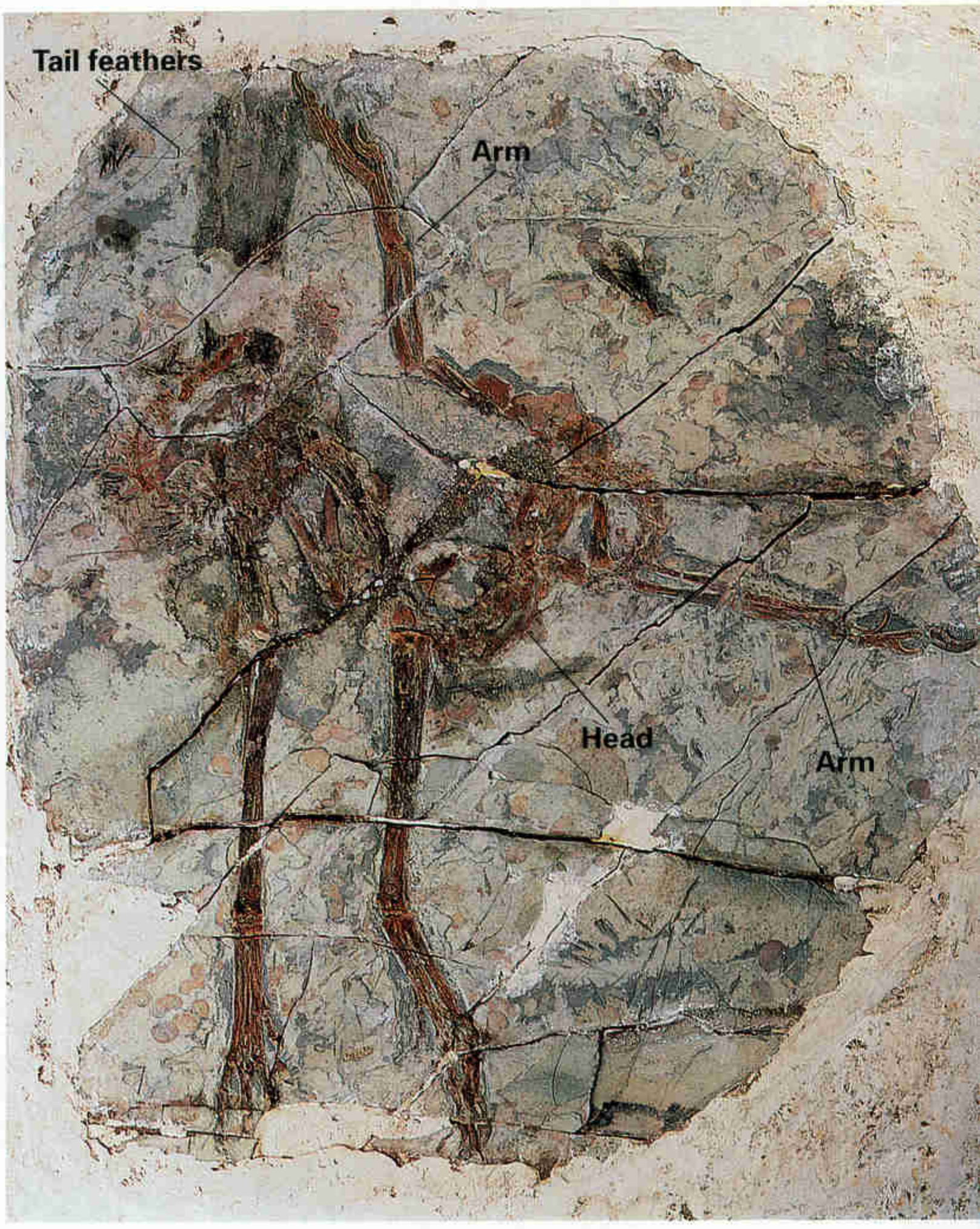
Shown near life-size, a *Sinosauropteryx* model peers down with arms extended, ready to pounce on a lizard or small mammal. If its body covering first evolved to preserve heat rather than for display, it would suggest that *Sinosauropteryx* was warm-blooded. Scientists have long debated the question of dinosaur metabolism.

(Continued from page 77)
earlier reptile, long before *Sinosauropteryx* feasted on its last meat.

That a small dinosaur with a hint of kinship to modern birds would ruffle feathers is hardly surprising. The ancestry of birds has aroused as much passionate debate as any puzzle in evolution, except perhaps the origin of life itself and the beginnings of our own tribe.

"We are obsessed with birds," says John Ostrom, a paleontologist at Yale University's Peabody Museum of Natural History, "in part because we envy their apparent freedom and ability to fly. Just look at our myths and symbols: Daedalus, the dove, the eagle, the raven."

I know this bewitchment. Birds leaped into my heart at an early age. There was the thrill of seeing a flight of snow geese pink-bellied in the western sun or a hummingbird so close I could almost feel the thrum of its tiny wingbeat. Human limbs are the heavy limbs of earthbound creatures. Birds are masters of the sky, superbly designed to defy gravity through the gift of wings, light bones, and airy, flexible feathers.



An 18th-century sage once proposed that birds arose from fish cast upon the land: "Fins turned to quills, the dried scales became feathers, the skin assumed a coating of down, the belly-fins changed into feet." Not until the mid-19th century did scientists note that birds were built a lot like reptiles but with a beak instead of teeth and three reptilian fingers hidden inside wings. No one had a snatch of evidence, however, to connect the two.

Then in 1861, while the bed of an ancient lagoon in Bavaria was being quarried for limestone, workmen uncovered a flat flag of stone with the remains of a birdlike creature. It was about the size of a crow, with the clawed fingers and long bony tail of a reptile but with the wishbone and feathered wings of a bird. The feathers resembled those of modern birds not just in number and arrangement but also in their asymmetrical shape, with narrow outer vanes that could neatly cut the air. The creature was named *Archaeopteryx* (from the Greek for "ancient wing") and eventually dated at 150 million years old.

The *Archaeopteryx* fossil arrived on the scene just two years after Charles Darwin's publication of *The Origin of Species.* Naturalist Thomas Henry Huxley, Darwin's whiskered, griffinlike champion, seized on the creature as a perfect example of a transitional form between reptiles and birds. Go down into the dark of time and watch the alchemy of evolution: the heavy bone of the reptile transforming into light, hollow bird bone, the forelimbs

Archaeopteryx and Protarchaeopteryx

Earliest known bird, 150-million-year-old *Archaeopteryx* (right) was the first fossil evidence linking birds and dinosaurs. The first of these crow-size creatures came to light in 1861 in the same Bavarian limestone that yielded a lone asymmetrical flight feather (above). A new Chinese fossil more than 120 million years old, *Protarchaeopteryx* (left) has more primitive, symmetrical feathers and may be how *Archaeopteryx's* ancestors looked.

stretching into wings, the shallow breastbone deepening to anchor massive wing muscles, the reptilian scales blooming into feathers. *Archaeopteryx,* Huxley believed, was a midcourse snapshot, evolution caught in the act.

When a small dinosaur named *Compsognathus* turned up in the same deposit as the ancient bird, Huxley noted the uncanny resemblance between the two and made a surprising suggestion: Birds did not just coexist with dinosaurs, they were close relatives.

But Huxley's critics raised the question, Isn't it possible that birds and dinosaurs look alike not because they were closely related but because they lived in similar niches and did things in a similar way? Separate development of like features, or convergence, is common in the history of life. Just look at the wings of a bat and those of a butterfly: Both allow for flapping flight but arise from different body parts and reflect no common ancestry.

Still, few cared to seriously challenge Huxley's dinosaur–bird link until the publication in 1926 of the English-language edition of Gerhard Heilmann's *The Origin of Birds*, which claimed that dinosaurs lacked wishbones, a defining avian trait. Birds and dinosaurs are likely related, said Heilmann, but only by way of a common ancestor from deeper in time. This ancestor, he suggested, was a small, slender, bipedal reptile that climbed trees and then learned to glide among them 230 million years ago in Triassic times.

So went the conventional wisdom for nearly half a century. Paleontologists occasionally stumbled on the fossilized bones of birds from late Cretaceous times, more than 65 million years ago. But nothing turned up to fill the abyss between these later birds and *Archaeopteryx*—or to illuminate what came before.

LATEST DISCOVERY

Caudipteryx Revealed

By PHILIP J. CURRIE

RESEARCH PROJECT

Supported in part by your Society

ON A ROCKY SLOPE near the tiny village of Sihetun in northeastern China fossils lie everywhere, imprinted on thin, brittle sheets of siltstone. Chen Pei-ji, a scientist from the Nanjing Institute of Geology and Paleontology, stoops often as he moves up the slope, gleefully retrieving splendid specimens of conchostracans, tiny freshwater crustaceans. Even my amateur eye easily spots stone fragments with the perfect impressions of mayfly larvae.

It is early June 1997, a year after the discovery of *Sinosauropteryx*. A team of three Chinese paleontologists has set out by foot from Sihetun, a huddle of low stone huts in the poor, arid country of western Liaoning Province. With us is Li Yin Fang, one of the farmers who unearthed *Sinosauropteryx* and sold it to the dealer who sent it to Ji.

As we ascend a gully in the slope, the air is cool and quiet but for the occasional shrill cry of a magpie. To our left, in a cliff excavated by Sihetun's farmers, is a layer-cake formation of siltstone, clay, and volcanic tuff, not yet conclusively dated but probably more than 120 million years old—the early Cretaceous period, a time of burgeoning creation.

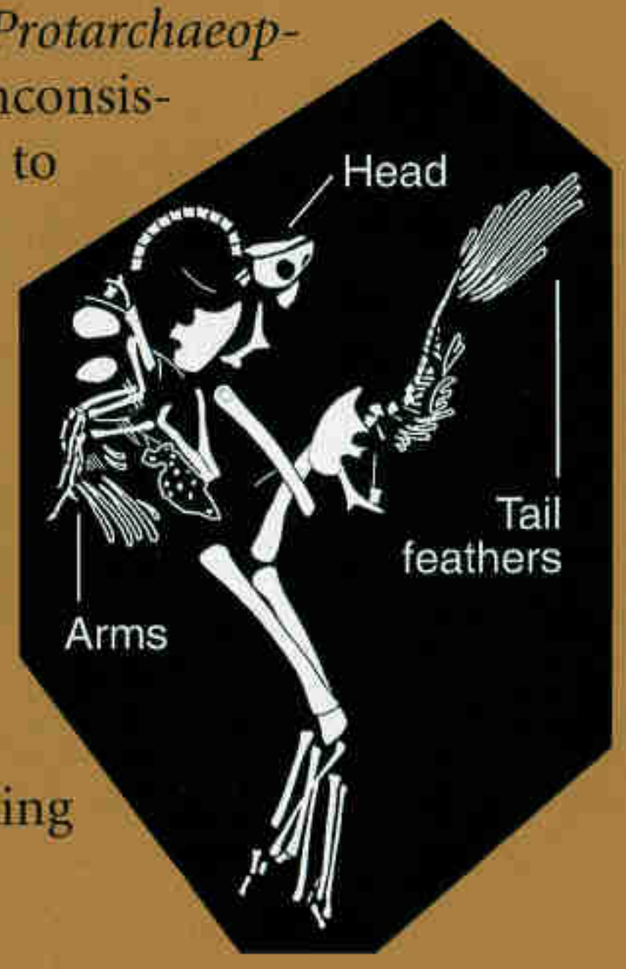
From these fossil beds have come millions of insects, hundreds of plant fossils, whole schools of fish that look as if they might at any moment flick into a new position. This was once a lake surrounded by lush vegetation and populated by a riot of insects, frogs, lizards, crocodiles, fish, mammals. Apocalypse came from the west, from what is now Inner Mongolia, where volcanoes erupted, spewing poisonous gas and ash that drifted east hundreds of miles. At Sihetun plants and animals died instantly, dropped to the lake bottom, and were buried by fine ash. Over time the layers of ash and silt settled and solidified, imprisoning and recording an ark of ancient organisms.

The first primitive bird fossil was found here in 1994 by a farmer who sold it to a trumpet player who gave it to Hou Lianhai, a specialist in avian fossils at the Chinese Academy of Sciences. Hou was instantly struck by the fossil's similarity to *Archaeopteryx*. About the size of a magpie, it had wings with long fingers and large, curved claws like those of *Archaeopteryx*. But where *Archaeopteryx* had a mouth full of teeth, this creature had a horny,

It was late when a visitor appeared in my dimly lit hotel room in Beipiao, China. Geologist Ji Qiang carried a cloth sack containing a broken slab of rock. He had just acquired it from a collector who works the rich fossil beds of Liaoning Province. These formations have produced more specimens relevant to the origin of birds than all the world's other sites combined.

The director of China's National Geological Museum, Ji believed he now possessed the best specimen yet of *Protarchaeopteryx*. This feathered creature is even more primitive than *Archaeopteryx*, a fossil considered the earliest bird since its discovery in Bavaria in 1861. Yet as we would soon discover, Ji had found something entirely new.

Three months later Ji and I were in Beijing, huddled in the red-carpeted conference room of Ji's museum. As we studied three specimens identified as *Protarchaeopteryx*, some inconsistencies began to appear. The three fossils were the same size and all had body feathers, but two had much shorter arms. Were we looking at males and females? Was



With surgical precision, technician Kevin Aulenback prepares a newfound fossil from Sihetun called *Caudipteryx zoui* (diagram at left), a curious creature that has further blurred the line between dinosaurs and birds.

Protarchaeopteryx a creature with much variation?

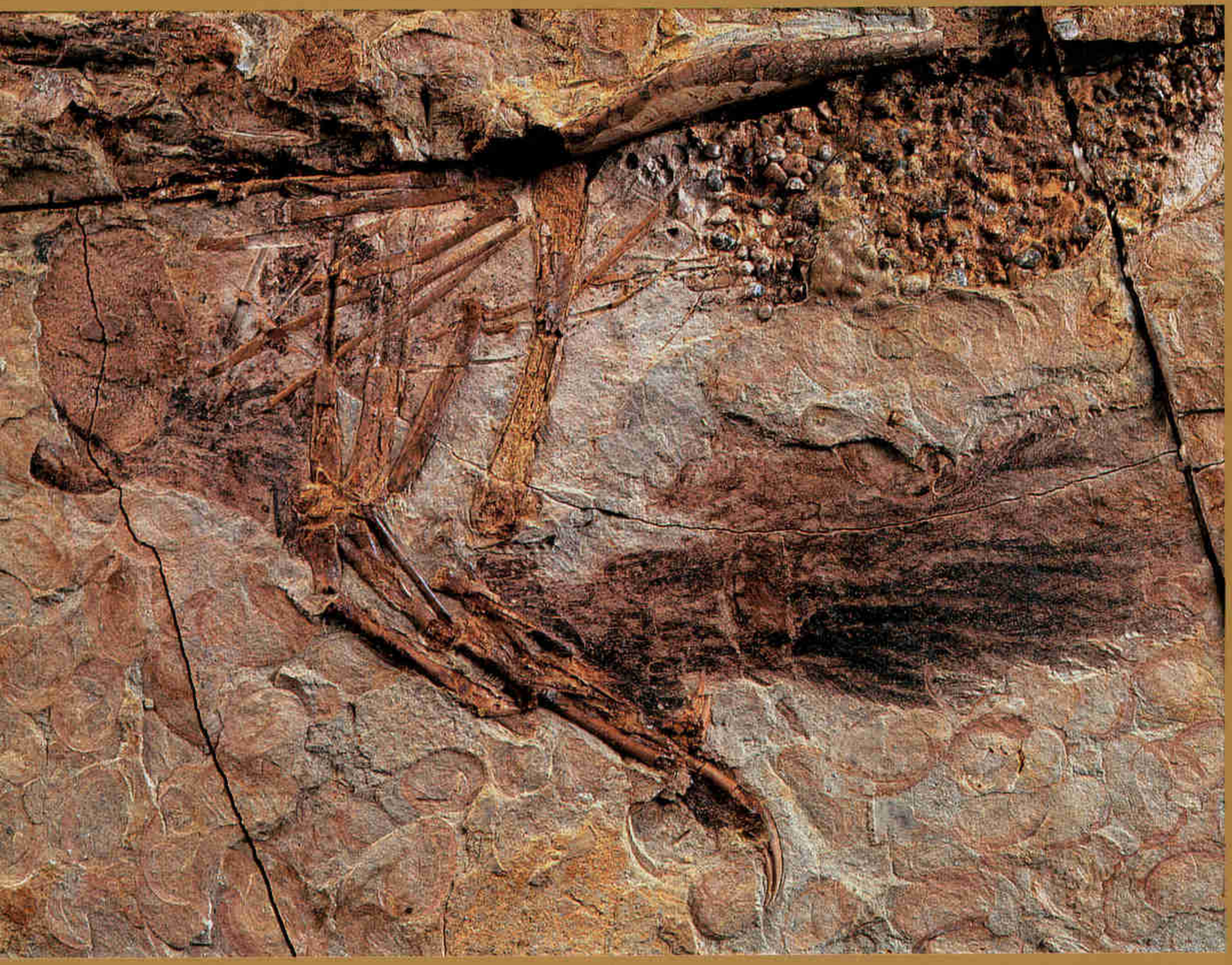
Fortunately Kevin Aulenback, one of the most skillful technicians at the Royal Tyrrell Museum of Palaeontology in Drumheller, Alberta, where I am curator of dinosaurs, was with us. As he cleaned the skulls under a microscope with a dental probe, we were startled by differences in the teeth. In both upper and lower jaws *Protarchaeopteryx* has *Archaeopteryx*-like conical teeth, except that they are serrated. But the two short-armed specimens had long, sharp teeth with deep, bulbous roots. And the teeth were confined to the front of the upper jaw, pointing more forward than down. They may have been incorporated into a birdlike beak with only the tips protruding.

Caudipteryx Revealed

We were now convinced that we had found a species never before seen. We named it *Caudipteryx*, or "tail feather," for the tail plumes that the creature likely fanned out for display. The feathers of *Protarchaeopteryx* and *Caudipteryx* seal their relationship to the earliest known birds, though neither animal had the ability to fly. In their body form they look less like that 19th-century evolutionary icon *Archaeopteryx* and more like those slender, meat-eating dinosaurs called theropods.

Caudipteryx becomes the fourth type of "feathered" animal from the remarkable Sihetun locality. It joins *Protarchaeopteryx* and *Confuciusornis*—a creature with relatively short, clawed wings that was probably one of the first birds to fly well—and *Sinosauropteryx*, one of the most important dinosaur finds of the 20th century.

My introduction to *Sinosauropteryx* had taken place during another memorable meeting with Ji. A year earlier at his museum he opened a



silk-wrapped gift box for me. Inside was a stunningly complete chicken-size fossil with a halo of feather-like structures on its back and tail, yet with the body of a theropod—a sensational find that made news as a possible missing link between dinosaurs and birds. Paleontologists and ornithologists are now grappling with redefining what constitutes a bird.

Caudipteryx and *Protarchaeopteryx* make the dividing line between dinosaurs and birds even less distinct and strengthen the theory that birds evolved from small carnivorous ground-dwelling dinosaurs.

These four discoveries were made within just a few years at Sihetun. I can't help but wonder what other treasures are to be found there.

Fossils of *Protarchaeopteryx*, *Caudipteryx*, and *Sinosauropteryx* and models of the latter two species will be displayed at Society headquarters through July 19.

Peering into a cloudy past, Aulenback and paleontologist Philip Currie (above, at right) examine *Caudipteryx* with Ji Qiang of China's National Geological Museum, a co-author of the specimen's scientific description. Below its feathered arms the fossil shows stones called gastroliths (left, at upper right). These were ingested to grind food, as in the gizzards of modern birds.

toothless beak. Until this discovery, Hou had been among the scientists who supposed that birds did not evolve beaks for another 70 million years. Here was a bird nearly as old as *Archaeopteryx* with a practically modern jaw. Hou named the bird *Confuciusornis sanctus*, which means "sacred Confucius bird."

Since that first fossil was found, hundreds of specimens of *Confuciusornis* have been plucked from these rocks. "So many birds packed into such a small area suggests a communal lifestyle," Hou tells me. I think of skimmers nesting gregariously on beaches, a gaggle of geese descending on marshes.

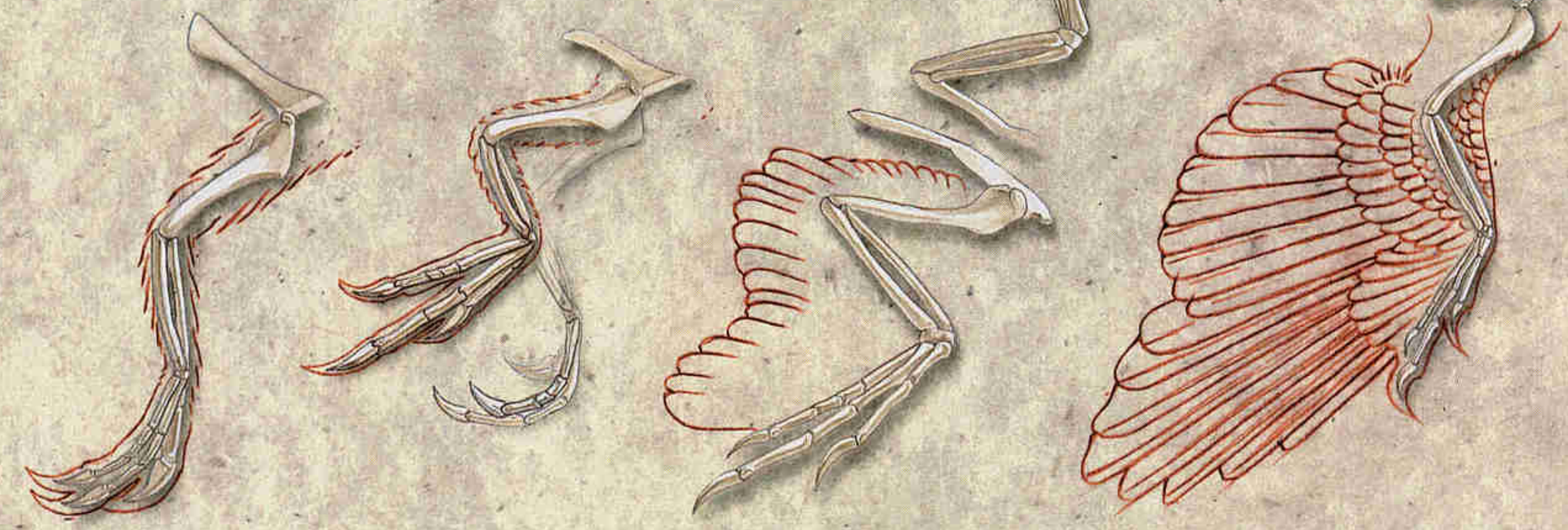
Later in his office in Beijing, Hou would show me his specimens. It takes up to two months to liberate the fine outline of a *Confuciusornis* fossil from its matrix of rock. What emerges is an exquisite glimpse of ancient bird-life frozen in stone: a female adult nestled skull to skull with a baby bird, or a male with long, lovely tail feathers like a fork-tailed flycatcher side by side with a female. Hou runs his fingers lightly over the fossils. Skull, beak, wishbone, tibia, wings. It's no big leap to imagine this bird snatching up an insect in mid-flight.

"*Confuciusornis* is the earliest bird we know of that could fly for any distance," he says. "It had wings nearly as primitive as those of *Archaeopteryx*, but it had other, more modern features—lighter bones and a shorter tail," which may have improved its flying skills.

From their reptilian beginnings the ancestors of birds evolved traits that would later aid the cause of flight. They gave up jaws with heavy teeth in favor of beaks, for example, and thinned and hollowed their bones (the skeleton of a three-pound frigatebird weighs but four ounces). Tiny air sacs and tubes evolved to honeycomb nearly every body space. Metabolism and temperature were souped up to sustain the chemical reactions that produce sufficient energy to stay aloft, so that a thrush now lives at what for us would be a fever heat, 105°F. The genome of birds is smaller than that of reptiles or mammals. Some scientists speculate that birds evolved a smaller genome to make their cells more metabolically efficient.

It's hard to imagine all this hot life and free flight arising from a sluggish reptile. But in 1964 John Ostrom, the Yale paleontologist, upended this image of reptiles as universally creeping crawlers. While digging for fossils in

EVOLUTION OF A WING



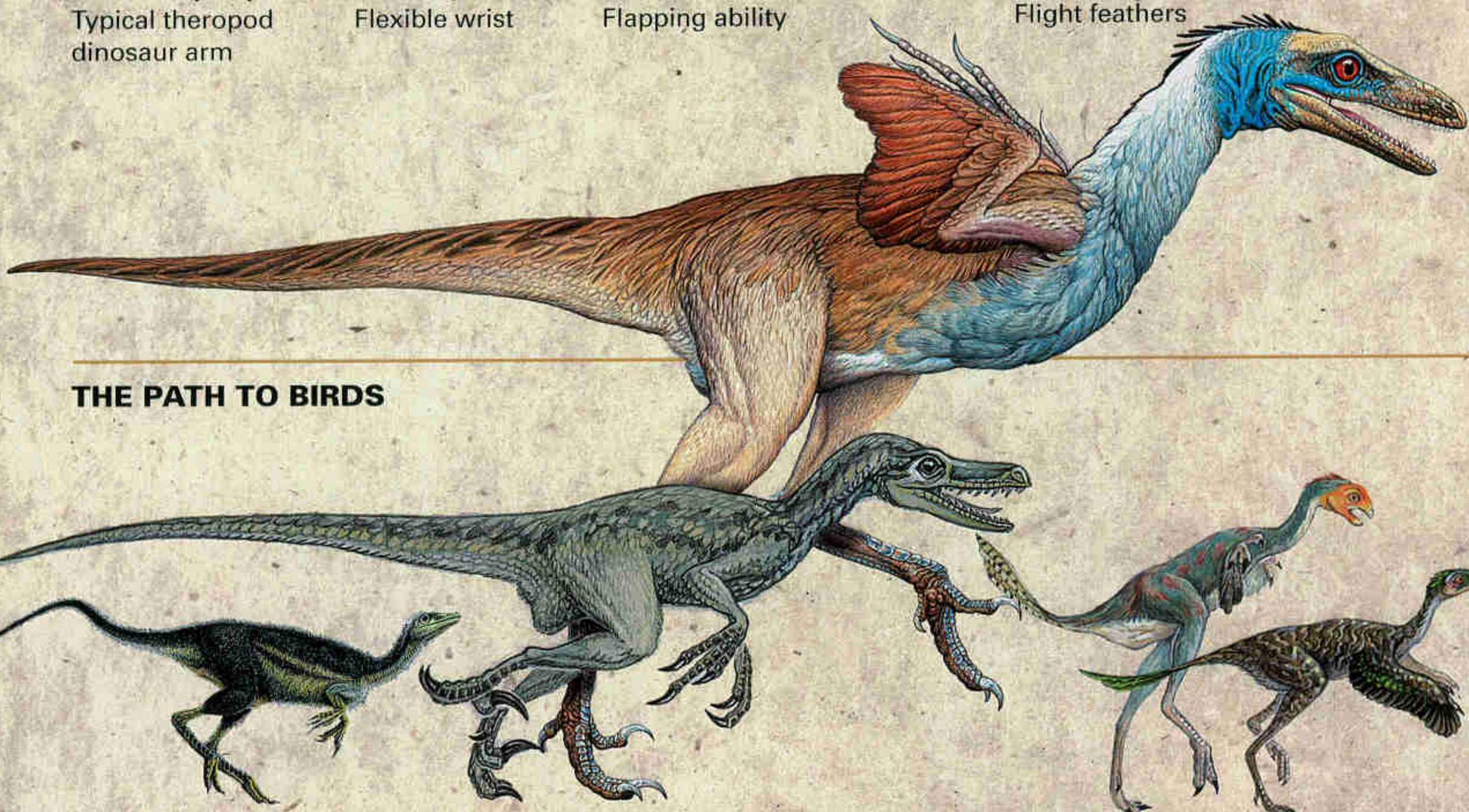
Sinosauropteryx
Typical theropod dinosaur arm

Velociraptor
Flexible wrist

Unenlagia
Flapping ability

Archaeopteryx
Flight feathers

THE PATH TO BIRDS



Sinosauropteryx
Covered with filaments that may have evolved for insulation or display, *Sinosauropteryx* was a ground-dwelling runner with short arms and three-fingered hands.

Velociraptor
This predatory theropod, whose fossils were found in Mongolia, was endowed with a wrist bone that permitted the animal's grasping hands to swivel, helping it capture prey. A flexible wrist is required for powered flight.

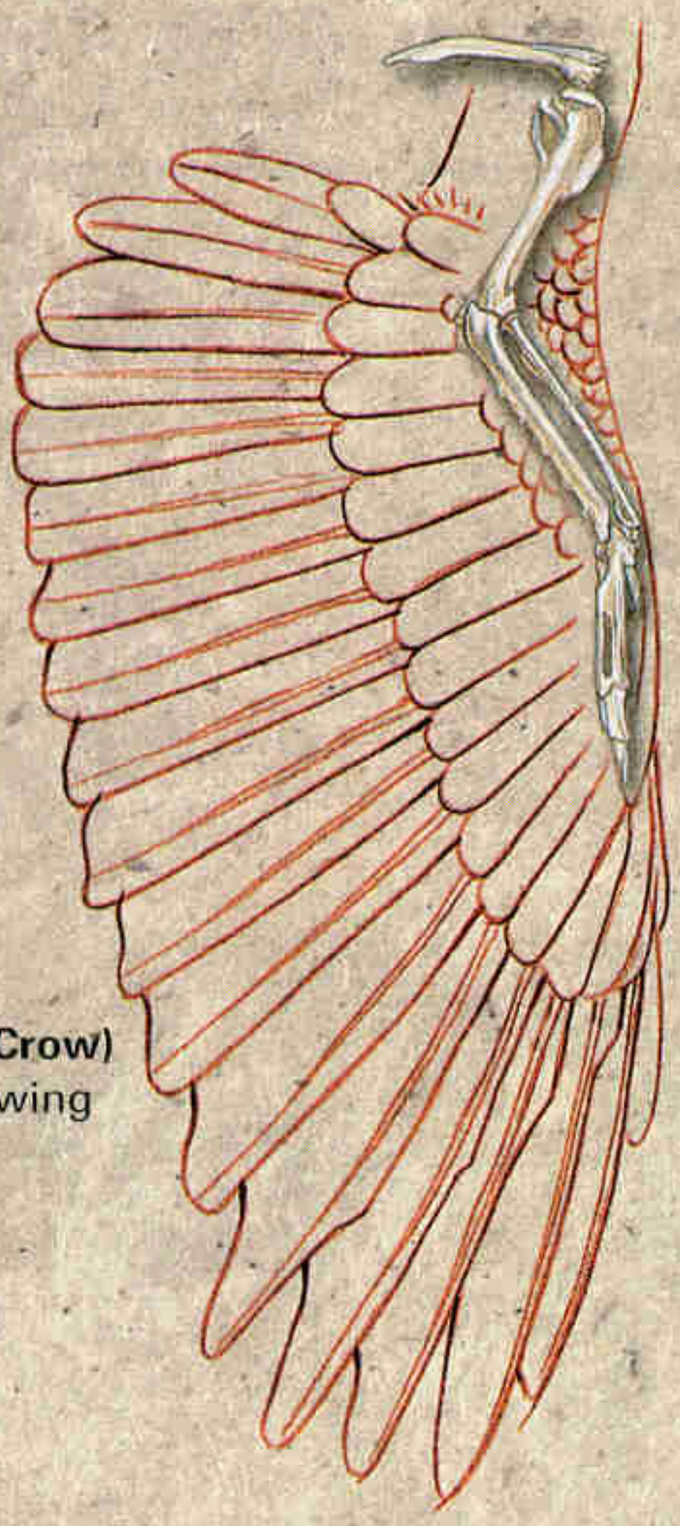
Unenlagia
Found in Patagonia, this flightless, eight-foot-long creature could move its arms up and down much as a person on a surfboard moves his arms for balance. A precursor to flapping, this action is critical to the flight stroke.

Caudipteryx
Straddling the realms of dinosaurs and birds, *Caudipteryx* is the latest in a series of sensational fossil finds in China. A speedy runner, it was covered with primitive feathers that lacked the aerodynamic quality necessary for flight.

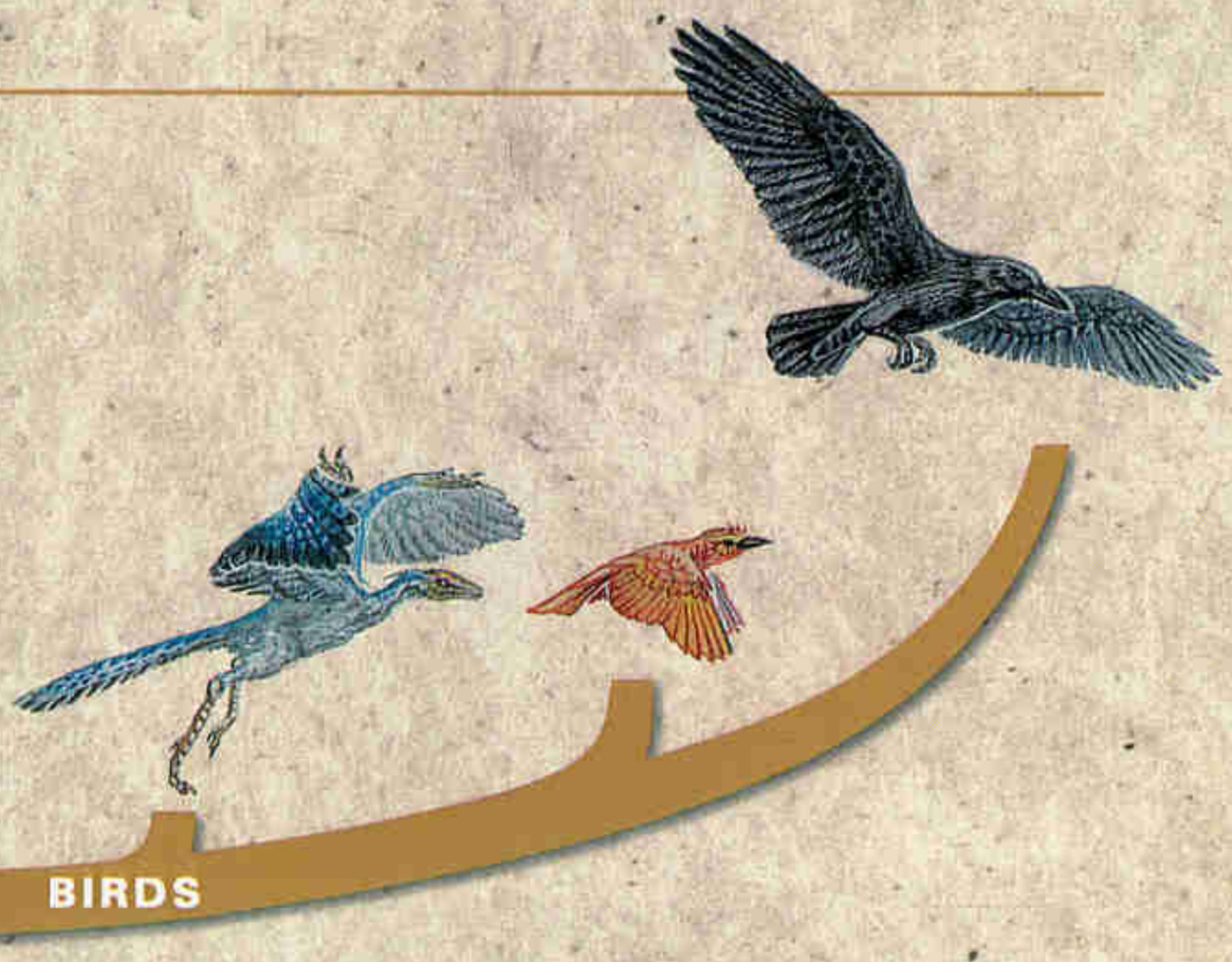
Protarchaeopteryx
Another discovery in China, *Protarchaeopteryx* resembles *Archaeopteryx* in many ways but is more primitive. The symmetrical feathers on its arms and tail appear longer than those of *Caudipteryx,* but it probably could not have achieved true powered flight.

DINOSAURS

Eoalulavis
First alula



***Corvus* (Crow)**
Modern wing



BIRDS

Archaeopteryx
The feathers of this bird's celebrated fossils are asymmetrical, with the leading edge narrower and more streamlined than the trailing edge. This enabled the wings to slice the air, permitting at least rudimentary flight.

Eoalulavis
Found in Spain, this bird exhibits the earliest known alula, a tuft of feathers attached to the thumb. By altering airflow, the alula permits good maneuverability and control at low flying speeds, crucial for takeoffs and landings.

Corvus
At the zenith of forelimb evolution, the crow and other modern avian species, with their shortened tailbones and expansive wing surfaces, represent the full flowering of the ability to fly.

SINOSAUROPTERYX BY MICHAEL SKREPNICK; *UNENLAGIA* BY ALDO CHIAPPE
BASED ON FOSSIL INTERPRETATION BY FERNANDO NOVAS

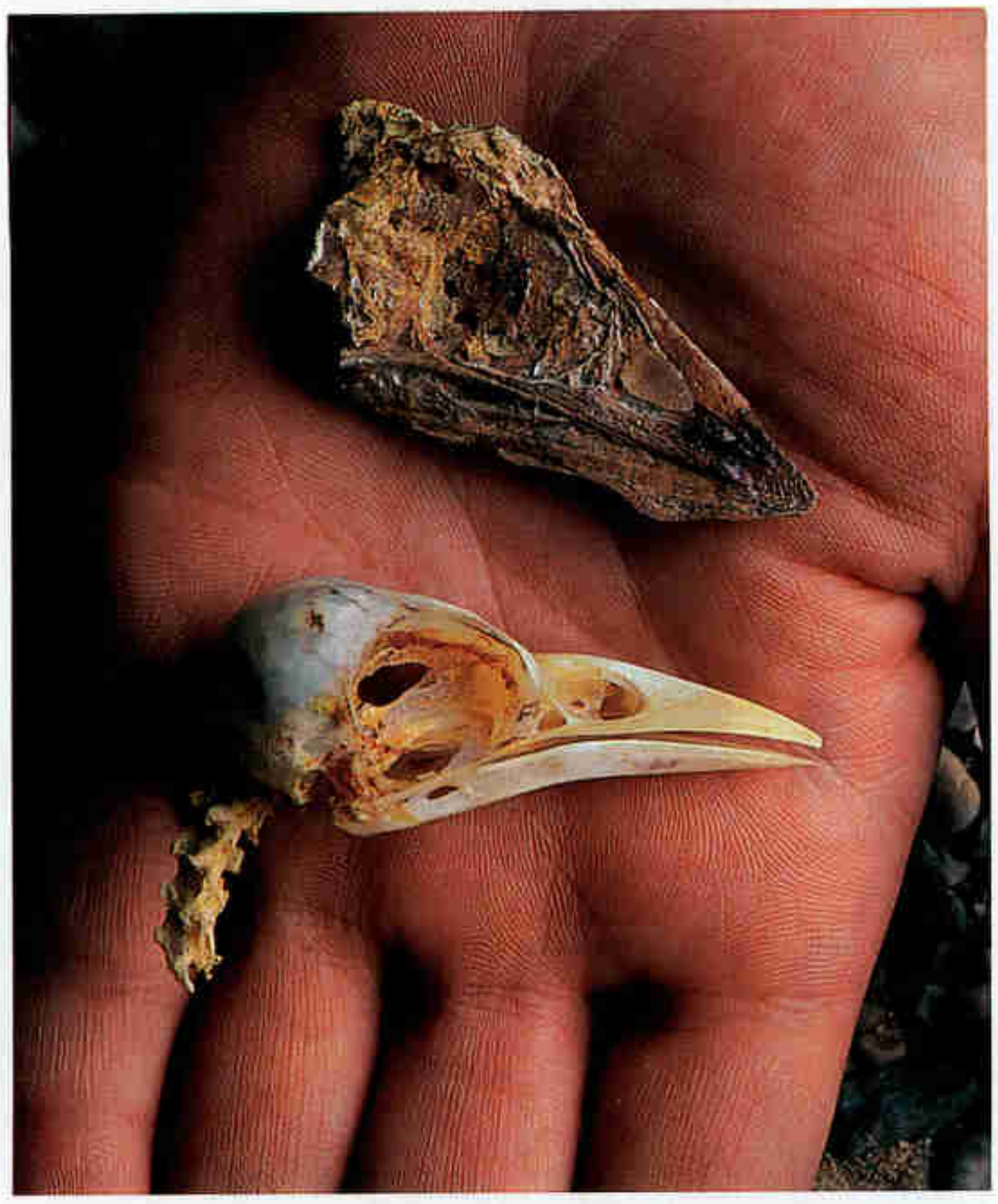
To Fly

Just as humans are mammals, birds belong within the great clan of dinosaurs in the view of most paleontologists. The idea that the defining traits of birds first arose in dinosaurs dates from the early expoundings of evolutionary theory. British biologist Thomas Henry Huxley, a champion of Charles Darwin, broached the notion in the mid-19th century. The idea was examined anew in the 1970s by Yale University paleontologist John Ostrom, who cited a host of similarities between *Archaeopteryx* and theropods.

This family tree (left) is not a chronological progression but rather an illustration of how the traits of the modern wing evolved in different creatures in different locations at different times. "The wing is a perfect example of how nature incorporates attributes that came about for unrelated reasons into a new structure," explains paleornithologist Luis Chiappe of the American Museum of Natural History.

Feathers that evolved to keep a ground dweller warm, for example, might give it the ability to glide and better catch prey, leading to more feather development.

A great boost to flight came with the alula, specialized feathers on the thumb that are essential for maintaining controlled airflow over the wings during slow flight. It made its earliest known appearance 115 million years ago in Spain in a bird called *Eoalulavis* (fossil above, with alula outlined).



Skulls of a modern Old World oriole, at bottom, and *Confuciusornis*, from the formation at Sihetun, have large eye sockets and prominent nasal openings. *Confuciusornis* is the earliest known bird with a toothless beak.

Wyoming and Montana, Ostrom uncovered a dinosaur about ten feet long and lightly built, with a huge, sickle-like claw on its foot. *Deinonychus*, or "terrible claw," was no lumbering creature but a fierce, leaping predator. Known as a coelurosaur, it represented a new variety of small, bipedal theropod, the meat-eating dinosaur group that includes *Tyrannosaurus rex*. *Deinonychus* was fleet of foot and agile as any hawk snatching up its rodent prey.

Ostrom is a smallish man in his 70s with a heron-like crest of white hair and a habit of cocking his head so that his better ear will catch the conversation. When he talks about birds, his eyes shine with childlike excitement.

A decade after unearthing *Deinonychus*, Ostrom launched a meticulous study comparing the anatomical details of *Archaeopteryx* with those of dinosaurs. He concluded that *Archaeopteryx* resembled nothing so much as a scaled-down version of *Deinonychus*. There were far too many similarities, he said, to be the result of convergence. He pointed in particular to a small, distinctive half-moon-shaped wrist bone shared by the creatures, which allowed them both to pivot their hands in similar fashion, a critical movement for catching prey—and for flapping flight. "Dinosaurs did not become extinct," he proclaimed. They live today in feathered form, as swallow, hawk, hummingbird, magpie.

TERRESTRIAL DINOSAUR to *Archaeopteryx* to swallow. This is not to suggest a direct lineage, grandfather to father to son. More like the loose line of lemur to ape to human. "We don't have the evidence to support any kind of direct lineal descent," says Ostrom. "There are too many gaps in the fossil record. We're in the business of connecting dots scattered in time and space."

In the past few decades a generous sprinkling of new dots has popped up around the world, a bizarre collection of birdish dinosaurs and dinosaur-like birds that tighten the lines. From 80-million-year-old strata in the Gobi desert has come *Velociraptor* ("swift robber"), a small, agile, predatory theropod with slim legs, clasping hands, and two key bird traits—a wishbone and a sternum, or breastbone. Also the skeleton and nest of *Oviraptor*, a theropod with a wishbone, clawed feet, and the birdlike habit of brooding its eggs.

In January 1996 the badlands of Patagonia gave up the partial remains of a 90-million-year-old two-legged dinosaur with surprisingly birdlike limbs. Called *Unenlagia*, "half bird" in the language of the Mapuche Indians, the creature folded its forelimbs much in the way birds tuck their wings and could move its shoulder joint to raise its front limbs as a bird would to start a downward flight stroke. Close on the heels of this discovery came news of one from Spain, a 135-million-year-old nestling with a primitive, dinosaur-like head but nearly modern wings.

These days most paleontologists are convinced that birds are a subcategory of dinosaurs. "The anatomical similarities are overwhelming," says Mark Norell, chairman of the department of vertebrate paleontology at the American Museum of Natural History in New York. He rattles off a few of more than one hundred shared features: wishbone, skull, three forward-pointing toes. The links between dinosaurs and birds are upheld by cladistics, a technique for drawing up family trees by analyzing the shared inheritance of specific

Confuciusornis sanctus

An aura of feathers surrounds a male, at left, and a female bird that lived more than 120 million years ago. Their size difference and the male's long tail feathers show that sexual dimorphism may have existed in birds at least since that time.

Found in Spain's Pyrenees and later fixed in synthetic resin, the earliest known bird nestling has dinosaur-like skull and teeth. Yet the bones of the 135-million-year-old fossil bear microscopic pits like those of modern juvenile birds.

features, such as specialized bones. At present cladistics firmly nests birds within the category of theropod dinosaurs.

Still, there are scientists who favor the notion that birds arose from a pre-dinosaur form, a small, tree-climbing reptile. These skeptics of the dinosaur–bird theory ask: If birds came from dinosaurs, why can't paleontologists find missing links of an appropriate age? "The majority of dinosaurs considered most birdlike are younger than *Archaeopteryx*," Hou Lianhai told me.

"But fossilization is a rare event," counters Mark Norell. "You could take all the fossils ever collected relevant to this debate and fit them nicely in my office." Norell and most other paleontologists think that dinosaurs such as *Velociraptor* represent vestiges of older ancestral lineages that did give rise to birds, probably in middle Jurassic times; the older species just haven't been found yet. Fossil beds in Utah dating from the late Jurassic have yielded teeth from what was probably a birdlike theropod, though as yet no complete skeletons.

BECAUSE OF THE LAY OF THE LAND in Liaoning, we move deeper into time as we climb, the rocks above us being older than those below. Li Yin Fang, the farmer, jumps down from the path into a deep pit to point out a thick layer of gray volcanic tuff. A wiry, energetic man with a quick grin, Li has been mining these fossil beds for years and has named the layers: thin yellow wax, great white band, thin red strip. "See that color?" he says, pointing to the gray volcanic layer. "If I was looking for fossils, this is where I'd dig."

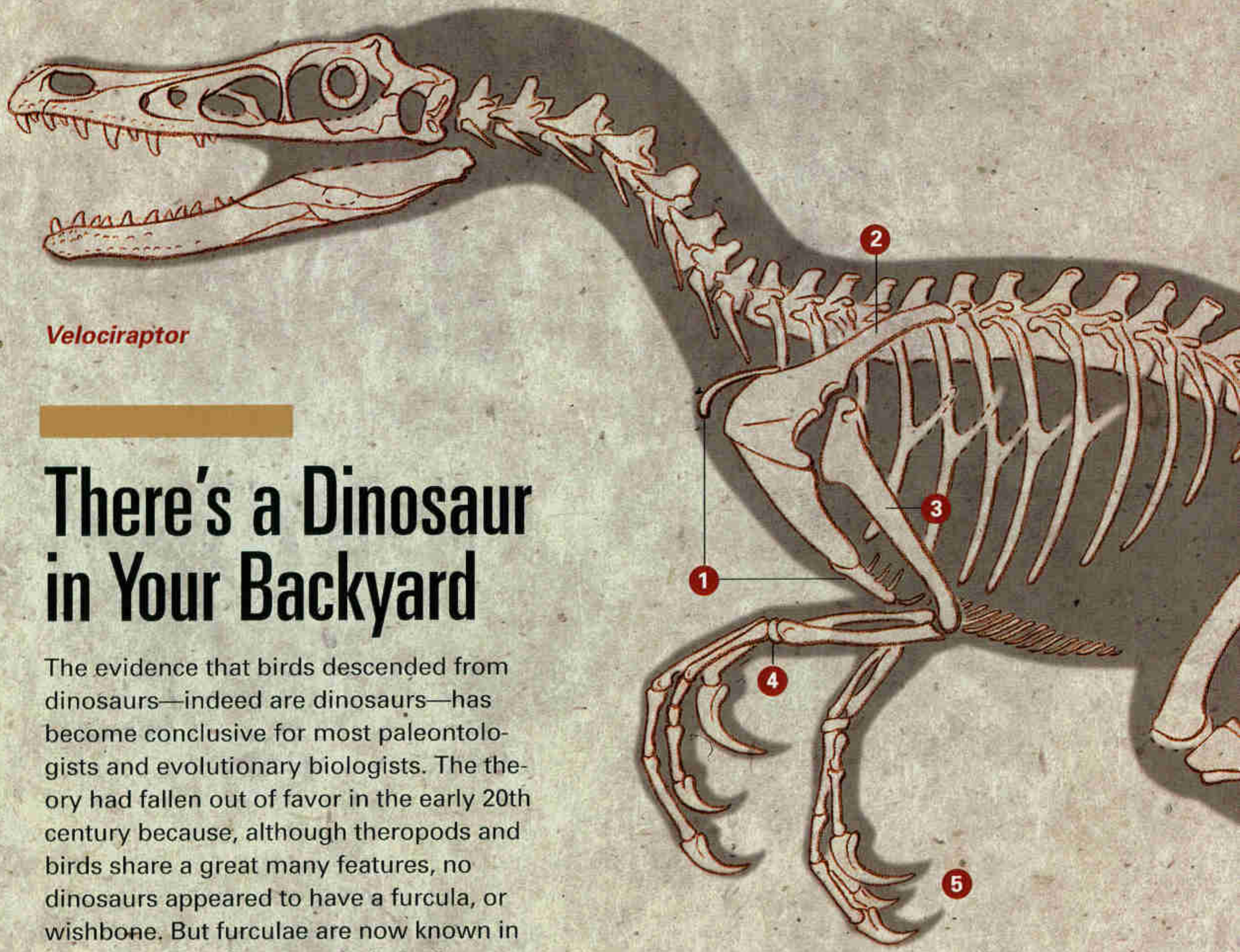
Dozens of deep pits pockmark the fossil beds of Sihetun. Though Chinese scientists and government officials applaud the farmers for discovering the bird fossils, they want to halt the destruction of the site and the smuggling of its treasures. "If a fossil isn't collected right, it loses its context," explains Hou Lianhai, "the kind of rock it was buried in, the animals that surround it, how it was buried"—in effect, its story. But stopping the smuggling may be difficult. For a farmer who earns less than $400 a year, selling a single bird fossil on the black market for as much as $1,400 can mean a quick lift out of poverty. And market demand is high. At a fossil show in Arizona last year about 50 specimens of *Confuciusornis* were up for sale, most fetching close to $5,000. To thwart the illegal trade, local authorities have filled many pits at Sihetun, posted warning signs, and offered to buy fossils already extracted from the site. But the illicit digging continues.

When we reach a high ridge, Li shows us the pit where farmers digging for Ji Qiang recently uncovered a new specimen of *Sinosauropteryx.* Nearby they found an extraordinary turkey-size animal with wings and tail feathers. It resembles *Archaeopteryx* but is more primitive and larger, with stronger legs, hence the name Ji has given it, *Protarchaeopteryx robusta.* Its

A new find is scrutinized by paleontologist José Sanz, director of work at Las Hoyas in central Spain. The site has yielded *Eoalulavis* and two other genera: significant links between *Archaeopteryx* and later birds.

feathers are symmetrical (unlike those of *Archaeopteryx*), suggesting that it could not fly. In the same area another flightless creature turned up—*Caudipteryx zoui*—this one with peculiar teeth, tail feathers, and long, symmetrical feathers sprouting from its second finger (see pages 74-5 and sidebar, pages 86-9).

These stunning new finds promise to illuminate the puzzles of early bird evolution, from the origin of feathers to the birth of winged flight. Are those fibers on *Sinosauropteryx* examples of protofeathers that might have helped conserve body heat or served in colorful mating display? What was the role of feathers on *Caudipteryx* and *Protarchaeopteryx?* Just where do those odd new creatures fit into the story of avian flight?



There's a Dinosaur in Your Backyard

The evidence that birds descended from dinosaurs—indeed are dinosaurs—has become conclusive for most paleontologists and evolutionary biologists. The theory had fallen out of favor in the early 20th century because, although theropods and birds share a great many features, no dinosaurs appeared to have a furcula, or wishbone. But furculae are now known in many species of theropods, including *Velociraptor,* unearthed in Mongolia in 1991. Its two clavicle bones are joined to make a V-shaped furcula (below).

A few scientists reject the dinosaur–bird connection. They see the similarities as convergent evolution—the development of like traits in separate species. To them

dinosaurs and birds share a common ancestor (which has yet to be discovered) but evolved along separate paths.

"But they have no physical evidence," says paleontologist Hans-Dieter Sues of Toronto's Royal Ontario Museum. "Only dinosaurs are anatomically suited to be the precursors of birds."

COMPARING DINOSAURS AND BIRDS

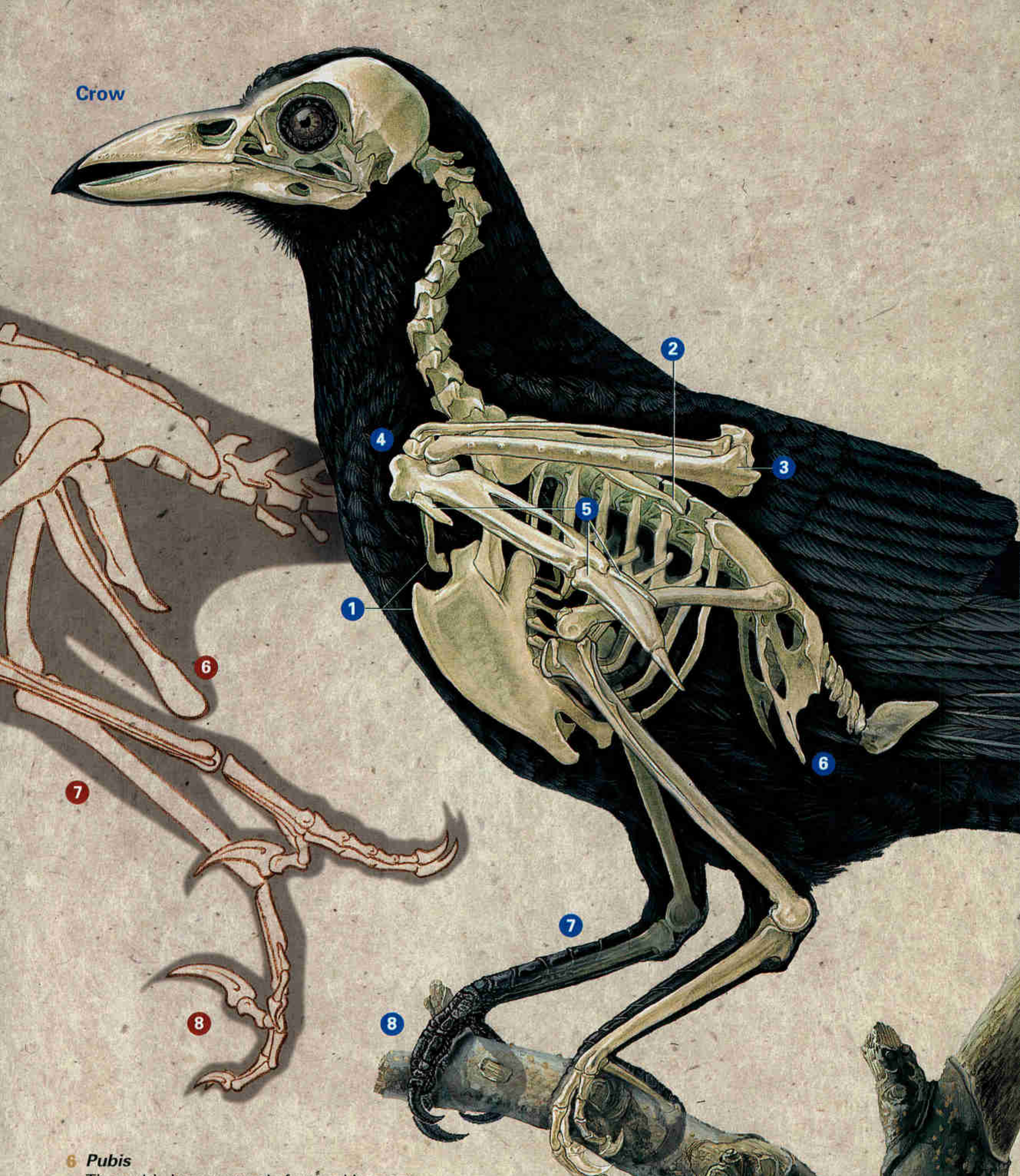
1 ***Wishbone and breastbone***
Many theropod dinosaurs have two clavicle bones fused into a furcula, or wishbone, as well as a sternum, or breastbone—both seen in modern birds.

2 ***Shoulder blade***
Birds and theropods have long, thin scapulae, or shoulder blades.

3 ***Bone mass***
Birds and birdlike dinosaurs have hollow and thin-walled bones, thus less body weight.

4 ***Swiveling wrists***
Half-moon-shaped bones enable the hands to fold against the lower arm and body.

5 ***Hand design***
Both birds and advanced birdlike theropods have lost two fingers. Of the three that remain, the middle is the longest.



6 ***Pubis***
The pubic bone extends forward in most dinosaurs but backward in birds and some theropods.

7 ***Legs***
Birds and theropods are "obligatory bipeds," meaning that their muscle and bone structure dictates moving on the two hind limbs.

8 ***Feet***
Both birds and theropods have three forward-pointing toes and a hallux. In dinosaurs the hallux is not fully rotated to the rear, as it is in most perching birds.

"The answers will require years of study," says John Ostrom. "Perhaps even centuries." More than a hundred years after the discovery of *Archaeopteryx*, scientists still aren't sure how well it could fly. Nor is it clear how its ancestors first took wing.

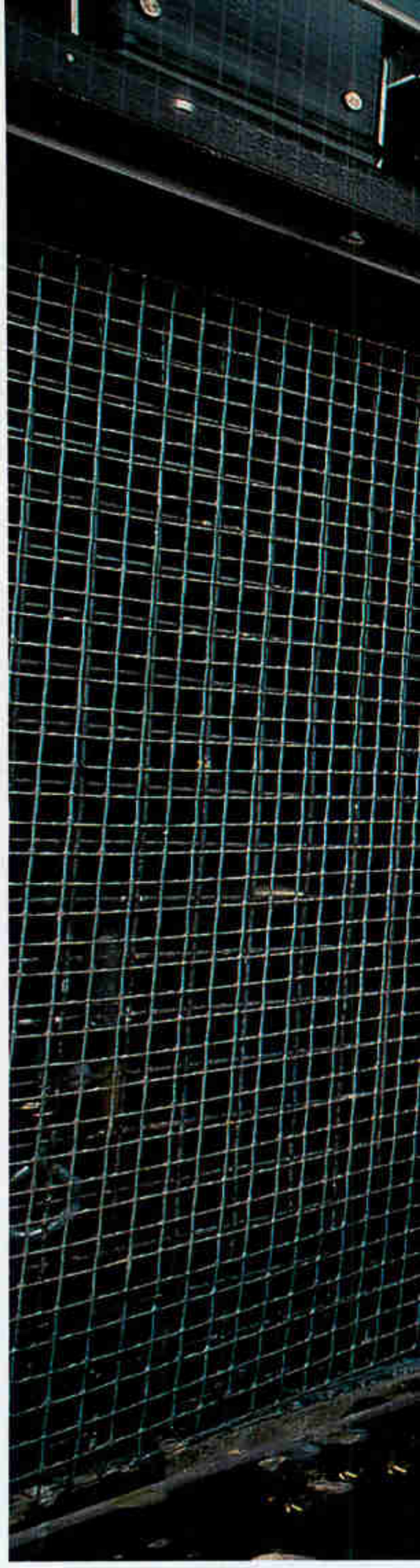
A small group of scientists believes that a tree-climbing reptile with the habit of jumping from tree to tree evolved wings that allowed it first to glide and then to fly. But most paleontologists contend that a small, two-legged dinosaur much like *Velociraptor* ran along the ground flapping its forelimbs and eventually developed the characteristics that allowed it to take off.

Ted Goslow believes that clues to the origin of bird flight can be found in living birds. An evolutionary biologist at Brown University, Goslow studies the bones and muscles used by birds in takeoff, flight, and landing to try to understand how these features might have evolved. He flies birds in wind tunnels and records their motion with high-speed film and with electrodes that measure their muscle activity to capture the subtle and complex movements in a single wingbeat.

"The flapping flight of a bird—the streamlined upstroke and powerful downstroke—is incredibly efficient," Goslow says. "The muscle that lifts the wing for the upstroke, for instance, can generate force ten times the body weight of the bird."

Recently Goslow and his colleague Sam Poore analyzed the wingbeat of starlings to decipher the role of this specialized muscle. They found that the muscle was critical not just for raising the wing but for repositioning it for the downward stroke—a finding that might shed light on *Archaeopteryx* flight. Anatomical evidence suggests that the bird had some ability to fly. But it lacked features essential to sophisticated flapping flight—the large, deep breastbone, for instance, that anchors wing muscles in modern birds.

"The modern bird wing also has this clever, weird pulley mechanism that allows the muscle to raise and twist the wing," Goslow explains. "There's no evidence of this mechanism in *Archaeopteryx*, suggesting that it might have been hampered in the trickier movements of slow flight, such as takeoff and landing, and was perhaps only at the threshold of true powered flight."



Avian studies take flight in a wind tunnel at Brown University. As graduate student Sam Poore, at left, controls air speed, evolutionary biologist Ted Goslow observes the wing motion of a starling. To prepare for the all-important downstroke, the bird must quickly position the wing high above its back. Goslow and Poore's study of *Archaeopteryx* shows that it lacked the shoulder structure necessary for rapid wing upstroke. If the archaic bird did flap its wings to remain airborne, it did so by some as yet unknown mechanism. Evidence of a modern shoulder didn't appear in birds until several million years after *Archaeopteryx*, another gap in the still puzzling history of the development of true flight.

BIRDS HAVE COME A LONG WAY since the first avian creature took wing. The most numerous vertebrates on Earth, after fish, they are exquisitely adapted to exploit nearly every airy niche. A peregrine falcon can dive out of the sky for prey at well over a hundred miles an hour. A hummingbird hovering above a flower beats its green and burnished wings nearly 60 times a second. A wandering albatross rides the currents over oceans for thousands of miles slung beneath ten feet of narrow wing.

Late in the afternoon at Sihetun I'm watching the antics of a magpie, cousin to the crow, flashing its iridescent black feathers. High above, swallows with swept-back, state-of-the-art wings are circling, diving in sudden turns. I have been trying to think of bird evolution as a smooth linear progression, but it is no

go. Cladograms and family trees may give the impression of tidy order, but there is nothing neat about bird evolution. Birds slipped through many shapes, with different traits evolving at different rates, odd mosaics of primitive and modern like those strange chimeras out of my childhood bestiary. The nearly 10,000 species of birds that live today are but the tip of an evolutionary iceberg of species that may run to hundreds of thousands.

On a hill just above me the Chinese paleontologists are hunched over a set of geologic maps that mark the spots of fossil finds at Sihetun with bright red painted birds. They are consulting on plans to study the fossils with x-rays, CT scans, and other high-tech equipment in a joint venture with a team of international scientists to examine the details of bones, eggs, beaks, and feathers. They are also planning to build a geologic corridor, "like a little Grand Canyon," Ji says, to study the formation layer by layer.

"We can't even begin to imagine what's in there," says John Ostrom. "A whole chunk of time is represented in those rocks that we've not found preserved anywhere else—a chunk that may very well hold the key to early bird evolution."

There are some who might say that the discovery of fossilized winged things scarcely affects our daily rounds. It's true, the slabs of bone and stone hold no promise for improving our health or material well-being. But they do offer a rare dose of perspective. Birds have been fluttering across the sky for more than a hundred million years. Our tribe has been walking the Earth for little more than four million. In our minds, sky has never been separate from bird. And for me, at least, the two are joined in an indescribable sweetness of union. □

Born again every spring, the Yukon River emerges from its winter silence with a roar of breaking ice, monitored by airborne hydrologists near Dawson. When ice jams up, water can rise several feet an hour. Dawson last flooded in 1979; a dike now shields the Canadian town. The few who live in this lonely landscape become even more isolated during breakup and freeze-up, when their river road turns treacherous.

By MICHAEL PARFIT
Photographs by JAY DICKMAN

The Untamed YUKON RIVER

Home, highway, hunting grounds: The 2,000-mile-long Yukon River is many things to the 36,000 souls scattered along its wild banks. At its mouth a hunter raises a harpoon to strike a seal (following pages), while far upstream a fisherman (above) listens to personal bulletins on "bush radio." The Yukon is touched only slightly by modern conveniences and even less by modern constraints.

"I HAVE A PSYCHIATRIST," said Coffee John. "He comes every year from Berlin. He says I'm normal."

Coffee John Bodnarek lives alone in a log house on the Yukon River. He has been to a town once in three years. From the picture window beside his bathtub he can sometimes see his two dogs chasing a bear.

Gathering its first trickles in the grinding darkness beneath the surface of the Llewellyn Glacier (opposite), the newborn Yukon bursts from an ice cave and offers a cold and silty drink to hydrologist Rick Janowicz (above). He and the author and photographer were the first to identify this specific unnamed stream as the great river's start.

For money he carves walking sticks and little wooden bears, which he sells to occasional tourists, who reach him by boat. He shoots moose for food. No matter how stable his personality, calling him normal compared with the rest of the world is like calling the Yukon River just another stream.

Elsewhere in North America people have turned away from their rivers. The waterways that were once arteries of life are now just barge canals or weekend playgrounds. But the Yukon is still what rivers used to be: burly, unreasonable, despotic, tough to handle, vital to the land and to the lives of its people.

In June of last year I went to travel the whole 2,000-mile length of the big river, from its source in British Columbia north through the Yukon Territory and then all the way across Alaska to the Bering Sea. With me went my wife, Suzanne, and our two golden retrievers, all crammed in a thirteen-and-a-half-foot inflatable boat. We had already traveled to several places on the river, but now we hoped to follow the Yukon to the sea, to learn it whole, and to find out why people like Coffee John still choose to live on this rough edge of water and land.

"This is it!" shouted Rick Janowicz, a Canadian hydrologist. We were in a stony gully next to the deeply crevassed Llewellyn Glacier, high above Atlin Lake in northwestern British Columbia. From a cave in a slope of ice a blast of gray water burst into the sunlight in full roar. Even at its beginning the Yukon is not tame.

A river does not start in any one place, of course, except to humans. It is the product of an entire basin. In the Yukon's case the basin that produces 230,000 cubic feet of water a second at the mouth is 330,000 square miles—more land than there is in Texas. Still, wanting to give meaning to geography, we seek out a source—usually the trickle that is

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MICHAEL PARFIT, who also reports on natural hazards in this issue, is working on a film about the Yukon. Freelance photographer JAY DICKMAN has covered four other wild rivers for the GEOGRAPHIC: Michigan's Fox (June 1997), Canada's Tatshenshini and Alsek (February 1994), and Papua New Guinea's Hunstein (February 1994).

Winding from sea to sea, the Yukon begins only 35 miles from the Pacific Ocean, flowing north and west to the Bering Sea. Its drainage basin is bigger than Texas, and its flow at the mouth is over half as great as the Mississippi's. Silt is its burden. About a thousand tons of fine sediment pours out each day from the source stream into Atlin Lake (opposite), just a tiny part of the one million tons that flows daily from the mouth at the peak of summer.

farthest from the mouth. It's as if, like a lion cub, a river's source carries all the genetic promise of the emperor of landscape that it will become.

Rick held up a bottle, looked at it, and took a drink of the milky water. He was hours late for a long drive home to Whitehorse, and I asked him about it. "That's OK," he said. "This is real."

TWO DAYS LATER, when I ran the boat onto my first gravel bar about 15 minutes after starting down the Yukon proper just upstream from Whitehorse, I knew running this river was going to be as real as it gets.

"Oh, shucks!" I shouted, or words to that effect. A couple picnicking on the far bank looked over. Oops. Not for the last time I yanked the outboard up and looked at a shining new gash on the prop.

"When you learn to drive around here," a riverman told me, "you buy five gallons of gas and a case of props, and you hope you run out of gas first."

Whitehorse, the first real city we met on the Yukon, was also the last. Its entire population—23,500 people—is twice the estimated population of the rest of the river. But like so many cities elsewhere that grew up using rivers, Whitehorse has turned its back on its river. Much of its waterfront is overgrown with shrubs and studded with old pilings left as monuments of the relatively recent days when stern-wheel steamers fought the current all the way up here from the Bering Sea.

"She's so beautiful," Whitehorse mayor Kathy Watson told me, describing the Yukon. "Some of the bank is not what we'd like. We'd like to make the river a gathering place again."

The riverbank renewal that Watson is planning may bring the river back into the city's daily life, but it can never recapture the bustle—no,

Like their gold digger counterparts of long ago, visiting showgirls paint and primp at Diamond Tooth Gertie's Gambling Hall in Dawson. In 1897-98 tens of thousands of prospectors swarmed here from all over the world. Today thousands of tourists come to gamble, pan for gold, watch wildlife, and visit the homes of writers Jack London and Robert Service.

the vast, disorganized, energetic hubbub—that existed on this river just before the turn of the century. As we left Whitehorse, with some 1,800 miles to go, we moved onto a stretch of river in which that past, though lying now in ruins, seemed more alive than the present.

THE AIR WAS FULL of fluffy cottonwood seeds and mosquitoes. On the banks wild roses bloomed in profusion. In the woods were shadowy shapes of old log houses. This was Hootalinqua, a village at the junction of the Yukon and Teslin Rivers that was briefly home to as many as a hundred people during the extraordinary frenzy of the gold rush of a century ago.

Sparked by a legendary ton of gold that showed up in Seattle in July 1897, a hundred thousand people from as far away as Greece and Australia poured north during the next year and a half. They headed for the Yukon's mouth or the brutal Chilkoot and other passes out of Alaska's ports, then worked their way up or down the Yukon to reach Dawson, where the Klondike River was paved with gold. Hootalinqua was one of dozens of towns that sprang up to service the throngs.

Most of those prospectors were men, but when Suzanne and I drifted into Hootalinqua, I thought of a remarkable woman named Anna DeGraf, who stopped off at this little settlement with a sewing machine and 600 pounds of supplies in October 1898, just as the river was freezing up for winter. She came looking not for gold but for her missing son, who was rumored to be in the Yukon Territory.

"It was 60 degrees below zero when we reached the barracks at the Hootalinqua," she wrote later. "The wolves . . . were so thick that . . . officials would not let anyone go any further."

DeGraf called the prospectors of the Yukon "boys." They called her "Mother." When she arrived at Hootalinqua, she was 59 years old.

DeGraf lived in the north until she became a great-grandmother (through a daughter), but she never found her son. How often did she see the face of her boy, whose absence drew her north as strongly as the gold drew others, in the many faces of death here? "In spite of all their gold dust," she wrote about sick and dying miners, "they had to leave it. . . . The ground was so hard that they could not be buried. Men were detailed to take turns guarding the boxes to keep the wolves away."

The Klondike gold rush is being celebrated with dozens of festivals, centennials, and other special events. Up and down the river, people will be remembering the stories of Jack London or the poetry of Robert Service, who lived in Dawson. It's unlikely in all the hoopla that many people will remember Anna DeGraf, whose own memoirs are straightforward and understated. But to me, as I walked among the wild roses of Hootalinqua, she seemed the very spirit of the thousands of everyday extraordinary people who abandoned comfort to meet this river on its own rough terms. What DeGraf wrote about another woman would apply to so many of them: "She went through hardships aplenty, but was never daunted."

Drifting among the bugs at Hootalinqua, we passed the remains of the steamship *Evelyn*, a ghostly superstructure rising out of woods on an island. This whole section of river was as eerie as an overgrown Inca temple. The quietness of ruin was not peaceful. As a recent traveler wrote, the place was like a stage on which "the play had ended but the curtain had yet to come down." It was a silence that remembered something big and important but could not say what it was.

In the Athapaskan tradition, Minnie Roberts dances a farewell for two men who died three years before. A three-night potlatch takes years to prepare, as the bereaved craft such gifts as mukluks, beadwork, and canoe paddles for friends of the dead. On the last night, prized wolf and wolverine skins are cut in strips and given away.

In search of gold near the Klondike, a Yukon tributary, Sharon Erickson blasts a hillside with a water cannon. She and her husband, John, will pass the runoff through a sluice box to sift out the precious metal. The glory days of the 1898 gold rush may be gone, but mining still underpins the economy of the Yukon Territory. In Dawson some bar tabs are paid with gold dust or nuggets.

As we alternately drifted and drove down the upper river, sometimes we passed what looked like busy driveways bulldozed to the water's edge. They were the loading ramps of gold miners who worked back in the hills. Because of all the ruins and the nostalgia industry built around them, visitors sometimes think the gold is played out. It isn't.

Back in March I'd gone up the ice-covered Yukon from Dawson on a snowmobile, looking for one of the dreamers, a hardworking prospector named Claus Schytrumpf.

The trip was chilling. Ever since high school I've remembered Jack London's frightening story "To Build a Fire," about a death at 75 below. Claus lives within a few miles of the scene of the story.

"The Yukon lay a mile wide and hidden under three feet of ice," London wrote. "It was all pure white, rolling in gentle undulations where the ice jams of the freeze-up had formed." When I drove a snowmobile upriver from Dawson, the river was just as white, just as deadly.

I parked the snowmobile and hiked half a mile up a creek. All I found was a tied dog and a rifle hanging in a tree. "Hello!" I shouted into the woods. Then Claus climbed up out of a hole in the ground.

He was young and slender. He wore a goatee and heavy yellow coveralls. He seemed pleased to have a visitor. He was German and had come here as a tourist in 1983. He had decided to stay and now sounded completely Canadian.

"It's just to keep a little bit of distance," he said, when I asked why he lived way out here in a 14-by-16-foot cabin he had built. "You don't have to put up with all that stuff—eh?—that goes on in the world."

Claus was digging to assess his claim. He was using a technique called shafting, which goes back to the days of the early prospectors.

He had made a boiler out of an old propane tank and attached it to a pressure hose. On one end of the hose he had clamped a long steel spear with a hole through its length—a "steam point." The steam point spurted vapor. Claus climbed into the hole, which was about ten feet deep, and started to hammer the point into the frozen ground.

The steam point bubbled, the fire crackled, the tank hissed, and the hammer clanked as Claus worked the ground for gold. He wouldn't know how much gold there was until he panned out the heap of rocks during the summer. I stood in the snow, watching. There was no telling of time here, or of century. This was what the silence remembered.

PAST AND PRESENT MINGLE through all seasons on the Yukon. In May 1907 NATIONAL GEOGRAPHIC carried a short article by a captain of the U.S. Army Signal Corps, George S. Gibbs. The story was called "The Breaking Up of the Yukon." In midsummer, as Suzanne and I drifted into Dawson, I thought back to the last time I'd been here, more than two months before. I had come to wait for breakup, which remains as Gibbs saw it, a "great event . . . looked forward to by the long-imprisoned inhabitants."

Dawson is a freewheeling town of about 2,000 residents, with half supported by the hard-nosed reality of gold mining and half by tourists nostalgic for the romantic image of gold mining. Dawson is Event City; it has a celebration of some kind almost every weekend. But its greatest event, breakup, is impossible to schedule and dangerous to take lightly.

It was late April when I arrived. The river was as white and still as when I had visited Claus in March. But the town buzzed with anticipation. Flowers were up, grass was green, mosquitoes were out, college-student job seekers had made a tent city at the north end of town, and everyone waited for breakup.

But behind the good cheer was a measure of dread. Breakup brings summer; it can also bring disaster. In 1979 the water behind an ice jam rose 30 feet in a few hours and almost washed away the town.

No matter how hard they try, people can't move ice jams. "The Air Force bombed a pile in '45," a resident of Galena, Alaska, once told me. "They might as well have spit on it."

What the Air Force couldn't do was easy for the river. On the afternoon of May 4 a small crack opened in the big sheet of ice. Brown water boiled out, incongruous on the placid white surface, like a bear snout snarling up out of a cake. Without a sound the sheet of ice began to slide downstream, like a train slipping out of a station.

Then the whole huge expanse of white was moving. It was too big to believe. It was as if all Canada was getting under way. The great white sheet turned as it moved, smashing into the shore and shoving enormous slabs of ice, some as tall as houses, up onto the bank, where they plowed up dirt and broke willow trees as if they were twigs. Chunks of ice broke and rammed each other, driving massive slabs on top of one another and smashing others to slush. The river looked like a landslide and avalanche all in one. Near the water's edge I could feel the earth shudder as chunks bigger than Cadillacs hit the shore. The slow start of the ice train had turned into a glorious wreck.

Behind the moving ice, water appeared, swirling and glistening, new in the world. Winter was a memory.

River ice, piled into humps by the turbulence of freeze-up, makes rough going for Canadian police Dan Parlee and David Wallace. "You've got to know how to lean," says Parlee, whose river beat includes isolated homesites up- and downstream from Dawson.

IN SUMMER it was hard to recall the upheaval of breakup, but there were other hazards. Near Dawson, about a third of the way to the sea, our inflatable boat began to leak air. I could hear it: a troubling hiss. What now? How long did we have before a tube went flat and dumped food, gear, dogs, and us into the river? But the boat didn't deflate. It wasn't a leak at all: The river's increasing load of silt made the water itself hiss as it moved.

On this sibilant stream we motored, then drifted, then motored again and moved deep into a rock-walled landscape of loneliness.

Except for the bus-bustling tour-group excitement of Dawson, the river was oddly empty. There were many cabins along the bank, but only a few were occupied—one by a farmer who sold produce in Dawson, one by a couple who raised emus, one by an artist who was away having a show at a gallery in Calgary, one by Robin Burien—the son of a man Robert Booth, a GEOGRAPHIC writer, had met doing a story that appeared in these pages in 1978. Most were empty. In one the door was gone, but lanterns, snowshoes, and socks hung around a big room, as if someone was about to return. But paths to the house were grown over.

Stopped cold by a cable to the ice, a clock records the beginning of the river's violent spring breakup at Galena, while a resident risks all to venture out among heaving floes. Time seems to stand still at a trapper's home 65 miles from Dawson (opposite), where Lisa Bigras displays a wolf skin.

As we approached Eagle, the first Alaska town, I remembered a book that must have been read with longing by almost everyone in my generation. It was called *Coming Into the Country,* and it featured the upper Yukon, centered on Eagle. When its author, John McPhee, was here, from 1975 to '77, young people from "outside" were building cabins all over on the Yukon. They were learning how to trap marten and lynx and butcher moose; they were becoming one with the wilderness; they were taking new names, like River Wind.

Those cabin builders were the advance guard of my generation's back-to-the-land dreams. Now I wondered how they were doing.

They weren't doing. They were done. Almost all those people who were so sure of their purpose had left. The log cabins they had built were falling down, and their gardens had gone to fireweed.

The story is similar everywhere on the river.

"People came to live a bit of that American dream—the pioneer, the trapper," Charlie Hnilicka, skipper of a river tug, told me. He'd been part of that, moving from Connecticut to an Alaska homestead in 1976. "They'd go out with rifle and ax and survive. About all of them have moved on to other things. They're still questing though."

But the next generation of questers hasn't shown up. "When I was 22, I was out there fishing and trapping lynx," said another former homesteader, Stan Zuray, who still fishes here but long ago moved to the town of Tanana. "Now there's nobody out there who's 22."

What has happened? In part, new government regulations have made it harder to homestead, even informally. But John Borg, the

veteran postmaster at Eagle, has a simpler answer: "They learned the reluctance of the country to allow itself to be lived off of."

We passed Eagle and got into trouble again.

"It's tricky," a riverman in Eagle had warned. "Islands and sandbars, islands and sandbars. You think you got it beat, and then you're in some back slough." He was talking about Yukon Flats, 150 miles downstream from Eagle. He was right. Twenty minutes into the flats I drove the boat onto a bar. Thump. Clunk. Curse.

We had ridden the muddy water easily through the Yukon-Charley Rivers National Preserve, the one part of the U.S. National Park System that includes the river. There the river valley was wide, bounded by stately ranges. But now the mountains backed away, as if to have nothing more to do with this devious flow, and the river occupied the entire landscape with illusions of deep channels that led to propeller-denting bars.

Like someone with a stoic face and a complex personality, the Yukon is hard to read. Except for most of the first hundred miles, it is opaque, a soup of glacial silt from the mountains far above and mud from the banks on which it gnaws. You can see into it about half an inch; dangerous shallows are hidden.

"It's nerve-racking until you can see the bottom," Charlie Hnilicka told me. He meant I had to learn to imagine it from subtle clues on the surface, the size of boils in turbulence, the rhythm with which the deep main current crosses from one bank to another in the curves, the steepness of the muddy banks themselves.

In the flats I felt like a river illiterate, so when a big aluminum skiff went past hauling nine drums of fuel oil, I tucked our little Zodiac in behind it and followed it for six solid hours through the maze.

Yukon Flats is a wildlife refuge, summer home to more than 1.5 million waterfowl. We saw few—they were raising young in backwaters as we passed—but the abundant life of this spread of water seemed constantly astir just over the horizon. People, too, were out in that stir, hunting and fishing and using that abundance to make their living.

"You won't like it," a canoeist warned the author about the trials of navigating this vast aquatic maze called Yukon Flats. Its 40,000 lakes and 6.5 million acres of wildlife refuge are summer home to 30 species of waterfowl that like it fine.

"We're in a ferocious battle," said Ben Stevens, waving a big knife. "We're working to ensure the survival of our people." He stood at a fish-cutting table on an island deep in the maze of Yukon Flats. He is a Koyukon Indian, a member of one of several Athapaskan groups living along the river.

It was 1 a.m., bright twilight. While we talked, his family members filleted 30-pound salmon, sliced them into strips, and hung them from poles. After 24 hours the strips would be moved to a smokehouse.

Ben Stevens was the director of natural resources for Stevens Village, a town of 99 people at the downstream end of Yukon Flats. (He is a descendant of the founders.) He grew up here but went to a boarding high school in southeast Alaska. He went to the lower 48 for college and then worked in health care administration. "I did the fast cars, fine dining thing, lots of money," he said. "It was an empty life. I moved back to Stevens to chill out, to stop the world from spinning so fast."

Now he was deeply involved in a new Alaska native movement. Like other villages, Stevens Village was agitating for more control over its expansive traditional lands. Ben Stevens was studying the moose, salmon, pike, birds, and other wild resources used by the people. "A lot of our ways are not written, so officially they don't exist," he said. "Now we're

"Driving on the river is part of living on the river," says Stan Zuray, who fishes 40 miles upstream from his home in Tanana. Zuray spends more than four months a year here, living in a cabin with no phone or electricity. He has caught up to 700 chum salmon in a fall day and makes weekly trips to town to pick up supplies and store his catch, 90 percent of which his 22 dogs eat. He also fishes for the federal government, which tags the salmon and graphs their movements. In his smokehouse (below) Zuray hangs salmon fillets over a smoldering cotton-wood fire for two days until done.

trying to put our traditional knowledge in the Western scientific box."

A rifle hung in a tree near the cutting table. It reminded me of Claus. It, too, was for emergency use against bears. Once, out in a boat with Stevens, I saw a bear, a lumbering lump on a sandbar, but when I pointed, Stevens quickly stopped me: "The Old Ones say don't point," he said. There were other things besides science in the box he carried.

OUR DOGS LEAPED ENTHUSIASTICALLY for the bank as we approached a campsite. Plop! They sank in mud up to their bellies. The spring's high water was falling. Slurp, slurp! The dogs wallowed around, which made us laugh until the same mud sucked off one of Suzanne's shoes. Yukon Flats was behind us. Mountains narrowed the river. We passed under the first bridge since Canada, which carries a road and the trans-Alaska pipeline across the river. Buses crossed, taking tourists to shoot pictures of the invisible Arctic Circle. There were 850 miles to go.

Two hundred miles downstream we caught up with Charlie Hnilicka and his river tug, *Ramona,* which was pushing two heavily laden barges downriver from Galena.

The tugboat *Ramona* pushes barges through dark water above Ruby, delivering critical supplies such as pickups, lumber, fuel, food, and beer. Only 2 of the 24 Alaska villages on the river have roads to the outside; the rest rely on airplanes or barges.

Suzanne and I tied the inflatable to the *Ramona* and climbed aboard to let Charlie do the work for a while. Forward, the barge was awash, deck laden with pickup trucks, four-wheelers, lumber, the stacked logs for an entire house, propane bottles, rolls of R-30 insulation, household goods wrapped in plastic, a folded crib, and an old freezer. On the freezer was written: "To: Eagle Island, 60 miles above Grayling."

Up in the wheelhouse a string quartet was on the tape player, and in the galley Grover Cleveland was eating fish and talking about Paganini. "It's tough to learn," he said, "but when you get it, it's really something." Cleveland, a burly deckhand, had a minor in classical guitar.

Like rivers in the 19th century, the Yukon is the main highway here. If you want something delivered from Fairbanks, say, to a town up here, you either take it in your own boat, pay 50 cents or so a pound for air freight, or ship it in the summer on a barge for less than a dime. Charlie, who owns the *Ramona* with his wife, Jan, operates out of a town on the Tanana River and runs up and down most of the lower Yukon seven days a week from breakup until the river freezes.

"That last trip of the season is the worst," he said. "The river is dropping, the ice is getting ready to run, you've got snow squalls, rain, wind, and darkness. You don't want to be out here any later than the first week in October."

We talked up in the pilothouse. Charlie's daughter, Julia, an energetic 11-year-old along for the trip, was down on the deck chatting happily with Suzanne and the dogs.

Charlie and I talked about wolves, which some subsistence hunters had complained to me about, saying protective laws made it more difficult to control them. But to Charlie they were part of the natural river's scene.

"Last couple of years we've been seeing amazing numbers of wolves," Charlie said. He pointed to the bank. "We've seen one pack more than once. Right down by that knob of a hill, lying on the riverbank. They just watch us go by."

We passed the spot. No wolves.

Eagle Island was a muddy bank with a cabin barely visible up in the woods. No one was there. Charlie maneuvered the *Ramona* over to the bank and put down a plank. He and Cleveland walked the freezer off and put it down on the gravel above the mud line, not far from a set of enormous, fresh grizzly bear prints.

Charlie filled out an invoice and put it in the freezer. He pulled the plank back on board and drove off downstream. In the distance the freezer stood there all alone, a little white monument to the informal commerce of the Yukon.

At Anvik we untied from the *Ramona* and let Charlie continue downstream. We walked up to the "washeteria"—a building with washing machines, showers, and toilets that is the hub of many of these small, traditionally plumbing-challenged towns. Signs near the pay phone announced the periods of subsistence gill-net fishing, a meeting on a domestic-violence grant, and fish counts.

"You know you belong here," said Malinda Chase, a young woman whom we'd met the winter before. She is part Koyukon. ("None of us are full-blooded," one Indian woman had told me. "We're all goofy.") Malinda had gone to boarding school with Ben Stevens. She had just moved back here from Fairbanks. Why?

"People are real here," she said. "You can rely on people, and there's much more flexibility. One system says get retirement, pension, everything. The other system says, 'What do you got going today?' "

"We all love seal hunting," says Thomas Wasuli (opposite), of his Yupik Eskimo community. Hunting and fishing provide an average of 724 pounds of food a year to each person along the lower Yukon. The spotted seal above will fill many needs: meat for food, skin for boots, hats, and gloves, and oil for fuel. Its bones will be carved into jewelry.

Downstream there were more people on the river—boats, fish camps, villages. Partly that's because there's more food—moose, birds, and, for those close to the coast, walrus, seals, whales, and fish. "There's more economy down there," Charlie had said. The communities change too. Holy Cross is the last big Indian town; the next, Russian Mission, is Yupik Eskimo. The towns are bigger: There are 600, 800, 1,000 people in each.

After Holy Cross the river took a big bend to the west, and I swear I could smell the salt. We were 200 miles from the sea. Smoke from vast forest fires inland smothered the landscape. It made the hills sketchy, the sun red, and the water amber brown. I drove across glassy water; the river widened, the horizon faded; it was hard to find my way. But at least the smoke meant people were working: Fire fighting is one of the main summer jobs on the Yukon.

"When there's thunder and lightning," an Eskimo said, "there's money signs in the air."

When any river nears the sea, there is a place where it divides into the many fingers that take it to the salt. The current slows, and the land can no longer hold the water together. Where the river disbands, there its delta begins. On the Yukon this place is called Head of Passes.

Suddenly reluctant to rush the last hundred miles, I shut down the motor and drifted.

The river had drawn in the many-colored waters of numerous tributaries. To this point it had joined them all into one mighty stream. But here the river changed its nature. It was over the hump; like a Koyukon Indian or Yupik Eskimo at a potlatch, it was starting to give it all away, distributing its gathered wealth—the great flow of water, the heavy load of silt—to the grander world.

The day after we arrived in Emmonak, the last town on our journey to the sea, Alaska's governor, Tony Knowles, came to town on a river tour. At a meeting he was accosted by a tiny Yupik woman named Mary Anne Immamak, the town's vice-mayor, who told him the politicians weren't paying enough attention to education.

Mary Anne was a political activist who didn't like politicians. "They're full of prunes!" she said later.

The problems of Emmonak, she said, were like problems in many river villages: alcohol, drugs, suicide. Recently a lot of kids had been sniffing gasoline. Why?

"Too much idling," she said. "Young kids now, they don't have to

chop wood. We heat with oil. They don't have to haul water, because when I want water, I just turn on the tap. We're spoiled, and now there's lots of room for mischief."

WE HAD ROOM on the river for only one more bit of mischief. On a Tuesday morning we took high tide the last 15 miles down to the sea. The narrow arm of river that went past Emmonak led away to the west, and as it went, the land got thinner and thinner until it seemed just a lace of grasses afloat on the water. We passed a single white tent—perhaps a whale hunter's camp—turned about three more corners, and then the land dwindled to nothing. This was the Bering Sea. We had made it.

We drifted on the remaining current. Sun-edged clouds floated overhead. Sandhill cranes flew along the land's edge. A dead tree stood on the shore like a sentinel. Suzanne dipped her fingers in the water. It was still fresh—as it would be far out to sea.

This place was just like the source: symbolic and momentous only in our minds.

After the boat was deflated and put away, Suzanne went to visit Mary Anne Immamak. She was in her little red house, baking rolls for an afternoon berry-picking outing down the river. On the table were a jar of strawberry jam and what looked like a 55-gallon drum of Crisco.

While she baked, Mary Anne talked about the river, and in the middle she was interrupted by a granddaughter, Michelle, who had been watching television: "Grandma, can I have some fish?" Mary Anne nodded.

Michelle scooted over to the refrigerator, took out a flat piece of dried salmon, and licked it, as she would lick an ice-cream cone.

Mary Anne smiled. "It's good to see the kids play along the river," she said. "They look happy."

Outside, Emmonak looked makeshift, like every other town on this river—junk on the riverbank, a clutter of beat-up boats, houses put together bit by bit by hand. But that was the nature of this river world, where you make a fish trap out of the trees that drift downstream, where you figure on not getting anywhere for a month at freeze-up, and where you make sure your boat is way up off the bank when the ice breaks.

If you want to live with this magnificent river, you have to adapt; your central piece of geography is moodier—and grander—than any human being. You become light on your feet, you adjust; you make do with what the river gives you, and you are glad that it is there.

"If you're not close to the river," Mary Anne said, "you're lost." □

The Yukon's wind and weather show in the face of Tom Prince, a Yupik Eskimo elder, who keeps warm in a beaver hat in Kotlik, near the river's mouth. Towns and villages on the river are strictly utilitarian but serve a loyal population. "It's not fancy here," says one woman raised along this extraordinary waterway, "but I love it."

Article and photographs
by JOHAN REINHARD

Research Update:

Atop the frigid summit of Pichu Pichu in the Peruvian Andes, archaeologists excavate a 500-year-old Inca tomb. Inside they found remains of human sacrifice and a gold female figurine (inset), fresh evidence of ancient rites of mountain worship.

New Inca Mummies

Luck once again was on our side. A heavy snow began to fall just as we finished excavating a 500-year-old sacrifice of an Inca girl. It was December 1997, and we were back on Nevado Ampato, the 20,700-foot volcano where we had chanced upon a now famous frozen mummy in 1995.* That discovery had taught us how to transport an unwieldy 80-pound bundle down a mountain without thawing out the body. Our success turned out to be perfect training for the past two years of fieldwork. Though we brought back nothing quite as spectacular as the Ampato ice maiden, we did discover four new mummies. We also found more ritual statues, many of them still wrapped in textiles. With these finds we shed new light on complex Inca rites.

*See "Peru's Ice Maidens," in the June 1996 GEOGRAPHIC.

Expeditions in 1996 and 1997, led by me and project co-director José Antonio Chávez, took us to several peaks worshiped by the Inca during the 15th and 16th centuries, when they ruled the Andes. We broadened our search of Ampato's summit, and on Pichu Pichu and Sara Sara we excavated burial platforms.

Pichu Pichu ranked as one of the Inca's most sacred peaks, perhaps because water draining from its flanks made irrigated farming possible in the area. In August 1996 our team climbed to the 18,600-foot summit and began digging into a raised, six-foot-high platform. It was arduous work, the ground frozen and the air so thin we gasped for breath after every few swings of a pickax.

On the third day we found the skeleton of a girl sacrificed to the gods. As an infant her skull had been molded into a conical shape. Though head deformation was a common custom in the Andes before the Spanish conquerors arrived in 1532, this is the first example we know of from an Inca sacrifice. Later we uncovered the skeleton of a boy. The pair may have been sacrificed together as symbolic marriage partners.

From the same platform we lifted out a textile too fragile to unfold, but it appeared that some 50 silver disks in rows of descending size were tied on. Beneath it lay a silver male figurine (right) wearing a crown of spiny oyster shell. At nearly 12 inches, it is one of the tallest existing Inca statues, perhaps representing the Inca emperor himself.

ILLUMINATE THE COMPLEX SPIRITUAL LIFE OF THE INCA.

NATIONAL GEOGRAPHIC
PHOTOGRAPHER MARK THIESSEN

Wearing her death clothes, a frozen mummy named Sarita

The emperor once dispatched 2,000 subjects to tend the sacred heights of Sara Sara, according to a 16th-century Spanish priest. In 1996 our team numbered ten as we searched for relics from that period. We explored the 18,060-foot mountain, tracking through snow up the middle peak (above). It was on the northern summit that we found the female mummy that villagers later named Sarita.

Excitedly we excavated the frozen remains (right),

CHALLENGES SCIENTISTS WITH AN UNEXPECTED POSTURE.

the skull clearly visible, and brought them to Catholic University in Arequipa. Under the guidance of co-director Chávez (right), we have begun to study the textile-wrapped skeleton, the feet still clad in sandals.

Examination of her teeth suggested that Sarita died at the age of 15. A CT scan of the bones revealed a skull fracture, telling us she perished from a blow to the head, just as the Ampato ice maiden had. She was buried with her knees flexed and pressed to her shoulders, a pose we had never seen in an Inca mummy. Was this intentional or accidental? We don't know.

Nearby, in a rock niche, we recovered a cache of figurines, probably gifts to the gods. They include (above, left to right) a 5.5-inch silver female clothed in alpaca; a smaller silver male; a llama of spiny oyster shell; and a gold vicuña, a wild relative of the llama.

MARK THIESSEN (TOP AND ABOVE)

A frozen mummy bundle with pottery stuck to it like barnacles receives the attention of co-director Chávez, who photographed our latest discovery on Ampato. A drought in 1997 had left its summit free of snow (top), affording us a rare chance to search the area.

We started with the slope down which the ice maiden had tumbled. In addition to wooden spoons and llama bones, we found textile pieces from her outer wrap. Sadly, looters had preceded us, and we have no idea what they may have taken. Evidence of plunder only strengthens our resolve to excavate as many high-altitude sites as possible in advance of thieves.

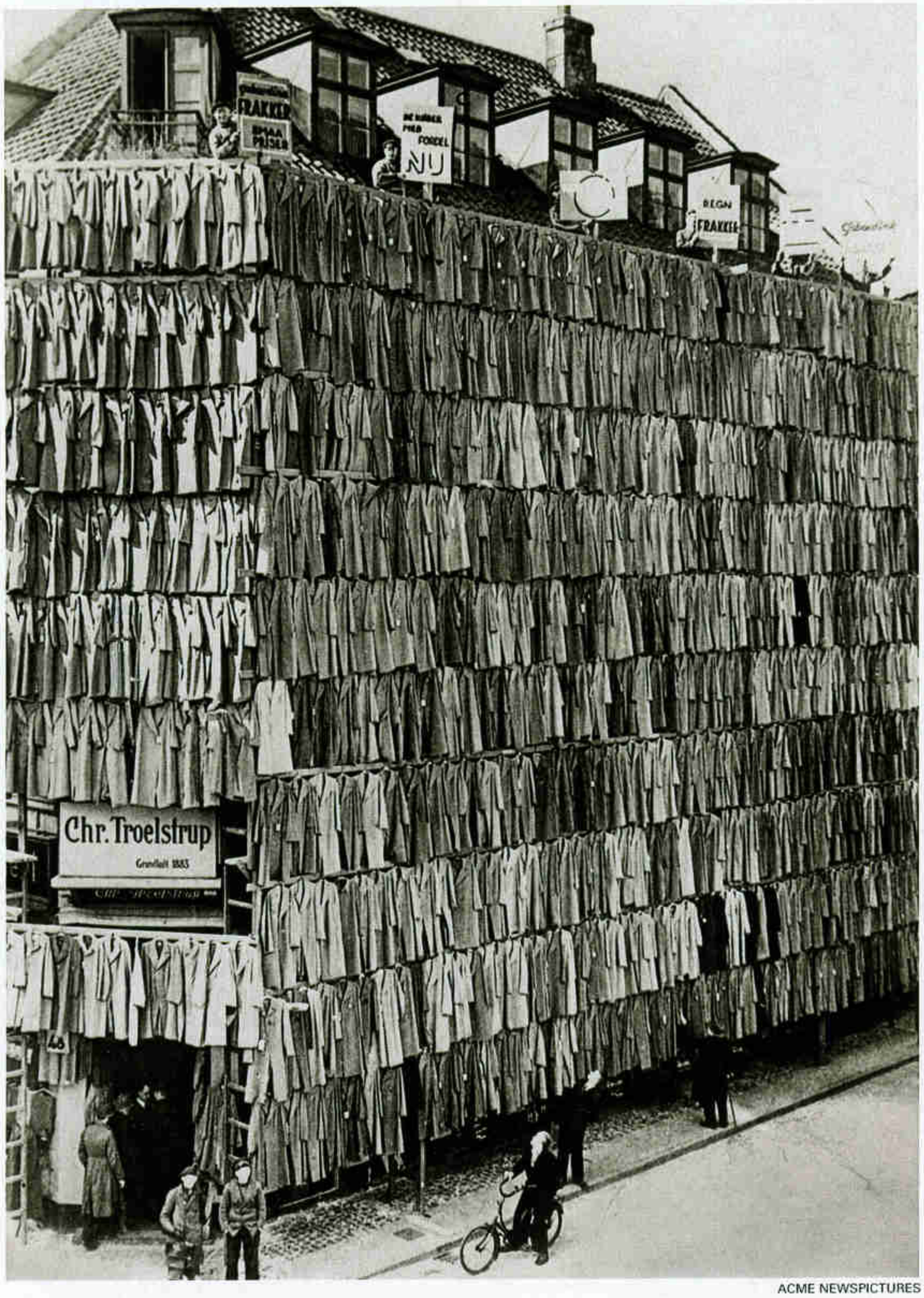
We spent much of our time investigating a plateau at 19,200 feet, where we were lucky to find this new mummy bundle, as it was unmarked by a platform or stone ring. Examination later revealed a skeleton scorched by lightning, like two burials we found on Ampato in 1995.

Beneath an empty burial platform elsewhere on the plateau we detected a thick layer of volcanic ash, giving credence to the theory that the Inca offered summit sacrifices in response to major volcanic eruptions.

Other forces of nature—snow and lightning—soon forced us to end our field season. As for our efforts to save and understand Peru's Inca heritage, we have just begun. □

National Geographic Society explorer-in-residence in 1997, JOHAN REINHARD has written three articles on his Andean research, as well as *Discovering the Inca Ice Maiden,* a children's book published by the Society.

AND A MUMMY FROM THE HEIGHTS OF AMPATO.



ACME NEWSPICTURES

■ FROM THE GEOGRAPHIC ARCHIVES

Overcoated in Denmark

The forecast was crowds in April 1936 when a Copenhagen clothier hung nearly a thousand gabardine overcoats on a framework surrounding his haberdashery to draw attention to excess inventory. "By the time the harassed policemen had convinced the storekeeper that his coats must come down, they had all been sold!" reads the caption for the photo, published in our January 1940 article "On Danish By-Lanes."

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On Television

■ NATIONAL GEOGRAPHIC EDUCATIONAL VIDEOS

Schoolhouse Rock: GeoKits for Teachers

VICTOR R. BOSWELL, JR.

The beauty of gemstones such as a cut citrine placed in a geode of amethyst (right) will dazzle students as they learn about Earth's structure in "Rocks and Minerals," a new GeoKit. These popular learning tools are made available by the educational outreach division of National Geographic Television. Built around the Society's educational videos, GeoKits are designed for grades six through eight. New GeoKits will include "Oceans," "Human Body: II," "Birds, Reptiles, and Amphibians," and "Electricity and Magnetism." Previously released titles are "Weather," "Pollution," "Astronomy," "Dynamic Earth," "Human Body: I," and "Cells and Microorganisms."

Created by curriculum specialists in close consultation with teachers, GeoKits bundle key materials educators need to teach units in science and natural history and to foster cooperative learning, problem solving, and critical thinking.

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CHRIS JOHNS, TONY STONE IMAGES

■ KIDS VIDEO SERIES

My Life as an Animal

Gus the Alligator pops out of his shell in the Florida Everglades and tells his story of growing up in *Tales From the Wild*, a new video series for kids. Each story is told from the point of view of a young animal making its way in the world—Tau the Lion, for example, or Cara the Sea Turtle. Packed with adventure and sing-along songs, the videos transport children into the animals' special environment. Not yet available in stores, *Tales From the Wild* videos can be ordered by calling 1-800-627-5162.

■ PROGRAM GUIDE

National Geographic Specials
NBC. See local listings.

National Geographic EXPLORER
TBS. Sundays, 7 p.m. ET.

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Programming information accurate at press time; consult local listings.

Look for the National Geographic Channel when traveling in the United Kingdom, Ireland, Scandinavia, Finland, and Australia.

Fighting in class? Mrs. Shurtz insists on it.

Recreating Pickett's Charge is just one of the innovative ways Jane Shurtz gets her fifth-grade social studies class into the spirit of American History. After the battle, her student "soldiers" write letters home describing what it's like to fight in the Civil War.

Mrs. Shurtz takes a very different approach when it comes to the Colonial period. She taxes student essentials like pencils and shoelaces so her class can understand the frustration the colonists must have felt.

The culmination of the year is The 20th Century Project. Students gather oral histories from family members and bring in heirlooms for class discussion. This project helps students feel more personally connected to this century's major events such as immigration, fighting in a World War, and living through an economic depression because they learned from those who experienced them first hand.

For showing that you can't change history but you *can* change the way it's taught, State Farm is proud to present Jane Shurtz with our Good Neighbor Award and to donate $5,000 to her school, Gray Elementary, in Springfield, Missouri. Hopefully it can help defray battlefield expenses.

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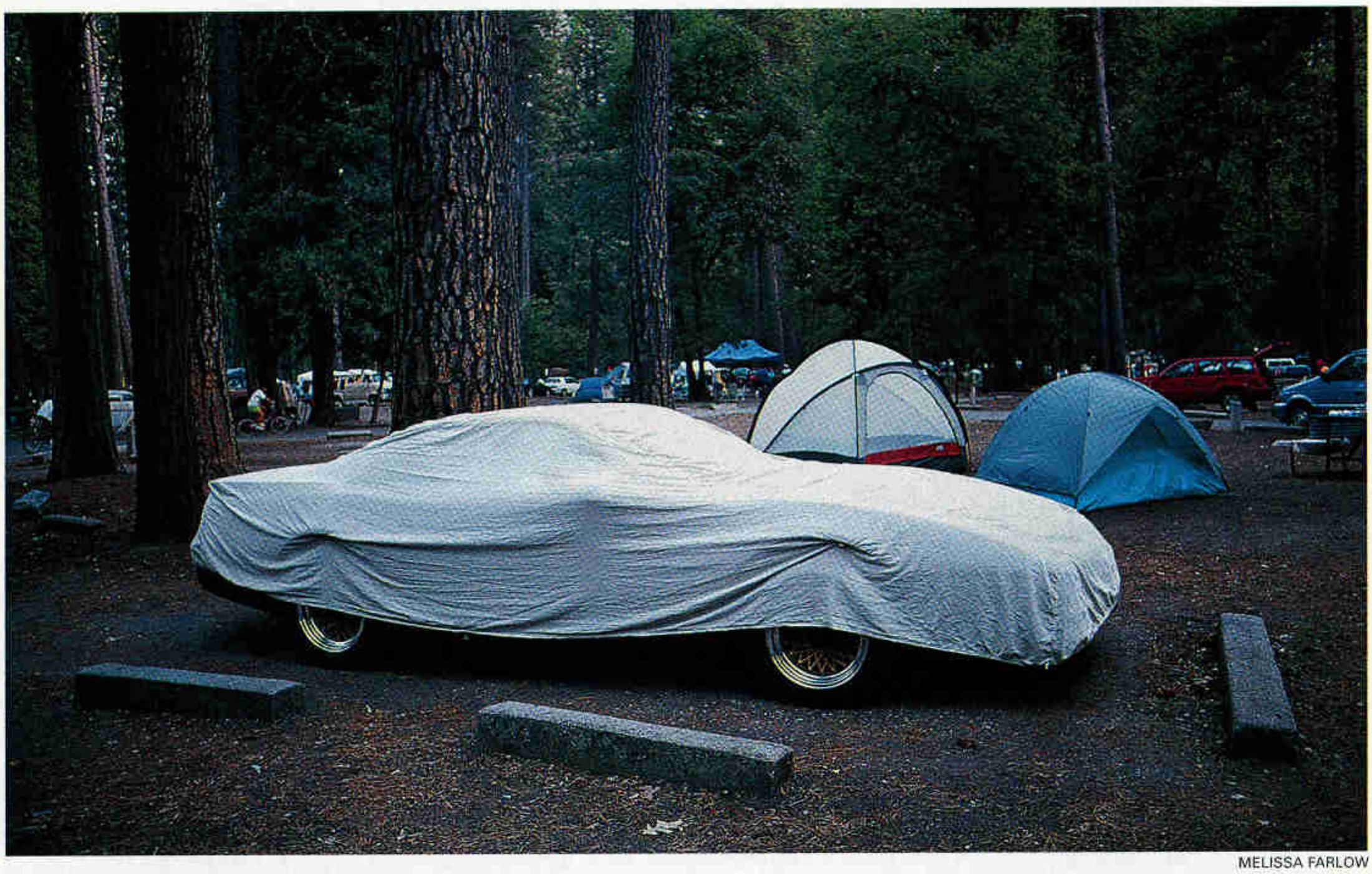
Earth Almanac



MELISSA FARLOW

Roadblock Set for Cars in Park

The almighty automobile reigns in Yosemite Valley: On peak summer days more than 7,000 vehicles crowd the national park. A plan approved in 1980 to reduce traffic stalled, then gained new impetus after floodwaters caused severe damage in January 1997. "The flood created a huge opportunity," says Chip Jenkins, Yosemite's chief of strategic planning. He and his colleagues will use 200 million dollars in federal recovery funds over a five-year period to redesign the park. Day visitors will park in satellite lots and ride shuttles to the valley, where employee housing will be greatly reduced. Five surrounding counties may eventually be linked by a regional transit system. Yosemite is not alone—Grand Canyon and Zion National Parks also aim to ban cars from congested areas.

FRANÇOIS GOHIER, ARDEA

Sperm Whales: Closer Bonds

Like bull elephants, male sperm whales are loners. Females live in groups (left), but males leave at about age six to wander the seas. Maturing 20 years later, they were thought to mate randomly. But DNA work at Dalhousie University in Halifax, Nova Scotia, shows that although female groups are primarily matrilineal, they sometimes include members related only through their fathers. This suggests that males revisit the same group or in a single visit mate with more than one female.

Wily Orchid Adapts Its Flowers to Insect Tongues

To lure pollinators, a South African orchid, *Disa draconis*, grows tubes that look like other flowers' nectar tubes. The orchids' tubes are empty, but flies keep visiting, probing with their long tongues. Yellow pollen then sticks to their faces. The orchid produces tubes of three different lengths. In one area, tubes 1.25 to 1.5 inches long match the tongue of this horsefly. In sand plains the orchid's two-inch tubes are visited by a longer tongued fly. In a third region tubes grow to nearly three inches, prompting botanists to seek an unknown fly with a really long tongue.

STEVE JOHNSON

Clawing Its Way to a Mate

An unmistakable "come hither" message is sent when a half dozen male fiddler crabs surround a female. Each waves its one enormous claw at her again and again, seemingly in unison. She descends with one into his burrow to mate. How did he win? Zoologist Patricia Backwell and her colleagues in South Africa and Panama filmed the behavior. Frame-by-frame analysis showed that the victor began his first wave about one-fifth of a second before the others. Competition to be the first to signal results in synchrony—a phenomenon also observed in the unified chorusing of katydids, the researchers say.

JOHN PONTIER, ANIMALS ANIMALS

M.S. LAWS, U.S. FISH AND WILDLIFE SERVICE

Coyotes Saved, Deer at Risk

After severe flooding in 1996 only 170 of more than 300 endangered Columbian white-tailed deer in Washington State's Julia Butler Hansen National Wildlife Refuge survived. Coyotes, already a serious problem, then picked off so many fawns that refuge personnel trapped and shot the predators. After a lawsuit by animal rights groups, the refuge agreed to consider nonlethal alternatives. "We plan to permanently relocate the coyotes off the refuge," says manager Joel David.

TEXT BY JOHN L. ELIOT

NATIONAL GEOGRAPHIC

*Inter*active

■ CD-ROM

This Card Store Never Closes

Another anniversary without a card to send? Try inventing a fresh excuse. Or fire up the Society's latest CD-ROM: Browse 3,000 Geographic photographs, use easy-to-operate design tools, and create an original. Students too will love this software, a boon for brightening reports.

MAURICE HORNOCKER

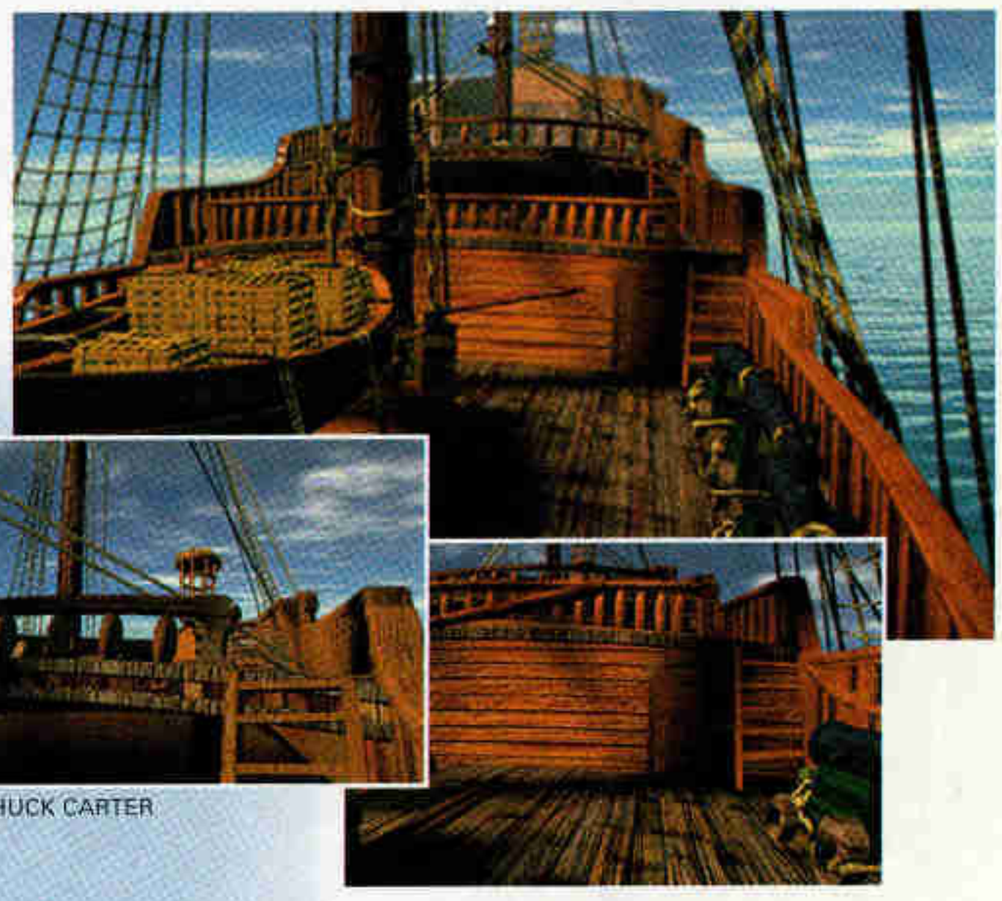
■ ONLINE

Our Website Starts Year Three With an Old Favorite and a New Adventure

Two years ago an enthralled online audience first walked the decks of the silver-laden galleon *Concepción* (below right). They examined her treasures and followed in her wake (below) as she lumbered from one Spanish outpost to another before sinking off Hispaniola in 1641. Now the popular feature sails anew on our award-winning site. Climb aboard at *www.nationalgeographic.com/features/98/silverbank.*

■ How often have you moved your residence? Did a new place mean a new you? Scholars are working with the Society to craft a global survey about human migration and the role that regional roots play in shaping identity. We seek participants. Glimpse our ambitious plan at *survey2000.nationalgeographic.com.*

■ Have natural hazards touched your life? Tell your story at . . . */media/ngm/9807/forum.*



ART BY CHUCK CARTER

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*On*Assignment

■ YUKON RIVER

The Goldens' Opportunity

The boat was piled with supplies that writer Mike Parfit and his wife, Suzanne Chisholm, would need for a 2,000-mile trip down the Yukon. But when Mike started the motor, the boat didn't budge. "It was too heavy. We had to find a stronger engine and lose a hundred pounds," says Mike. But the golden retrievers stayed. "Our marriage survived a month sleeping in a four-by-eight tent with two big, damp dogs," says Suzanne. "It can survive anything."

JAY DICKMAN

■ INCA MUMMIES

Johan Online

It was high-altitude, high-tech for Johan Reinhard. The Illinois-born anthropologist, a 30-year climbing veteran who has scaled more than a hundred Andean peaks, made notes on a laptop, cruised the World Wide Web, and sent e-mail during excavations on Peru's 20,700-foot Nevado Ampato. After finding a 500-year-old Inca mummy, Johan used a satellite hookup and called colleagues in Arequipa to bring supplies for five more days at the site. "I also waited out a snowstorm," he says, "talking on the phone."

JOSÉ ANTONIO CHÁVEZ

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Slender Loris *(Loris tardigradus)* **Size:** Head and body length, 18 - 26 cm **Weight:** Average 100 - 283 g **Habitat:** Tropical rain forest, woodland and swampy coastal forest in southern India and Sri Lanka **Surviving number:** Unknown
Photographed by Gerald Cubitt

WILDLIFE AS CANON SEES IT

The slender loris maneuvers silently through dense forest at night, moving just one hand or foot at a time as it walks along the top of horizontal branches. Though delicate in appearance, the loris is extremely flexible and strong, yet it never leaps. Anchored by tight-gripping feet, it often hangs suspended, enabling its free hands to grab an insect, or to merely stretch, groom, or play. At dawn, the little prosimian, a suborder of primates, sits on a branch and curls up to sleep. Habitat loss and fragmentation, and hunting in some areas, seriously threaten the slender loris. As a global corporation committed to social and environmental concerns, we join in worldwide efforts to promote greater awareness of endangered species for the benefit of future generations.

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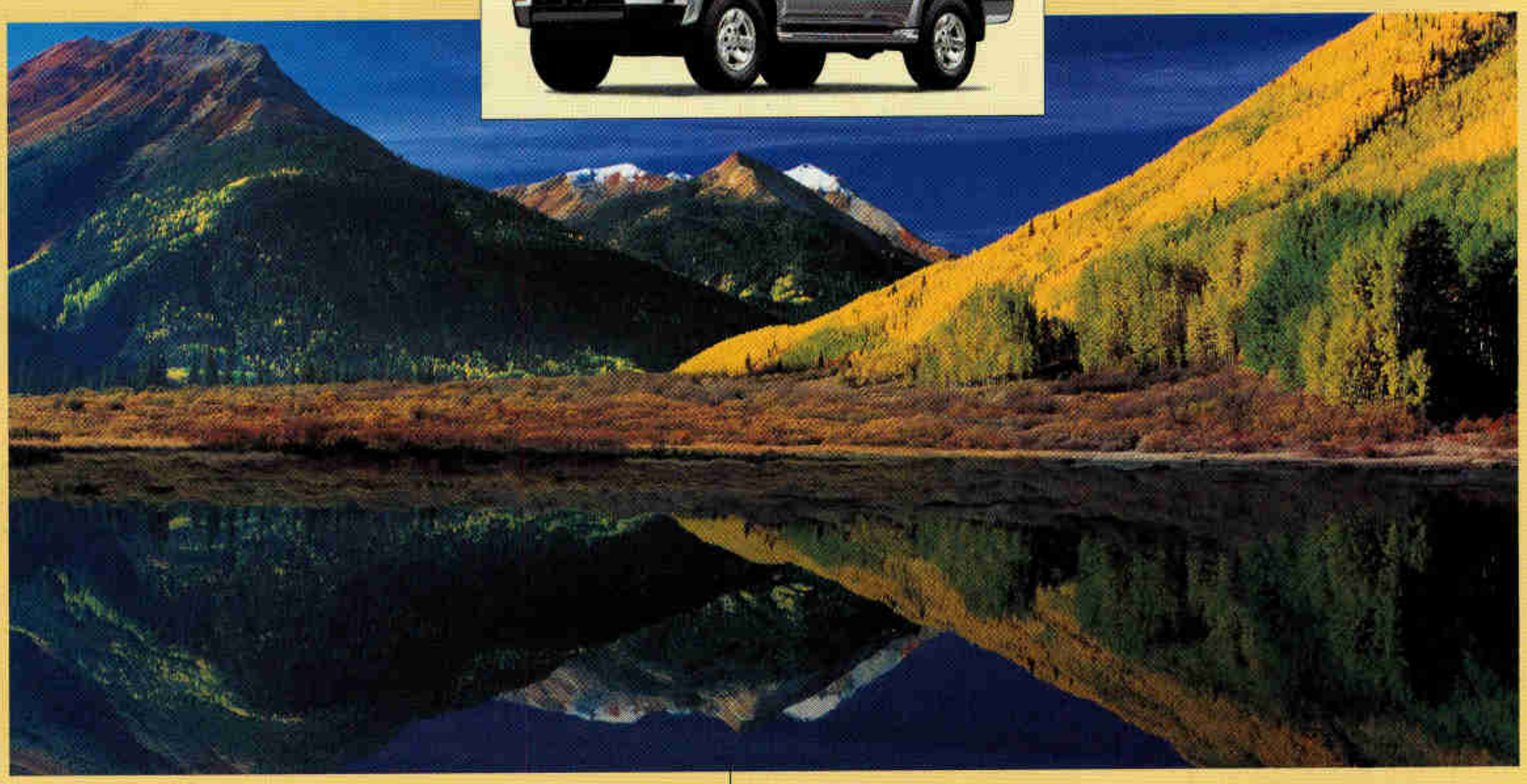

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